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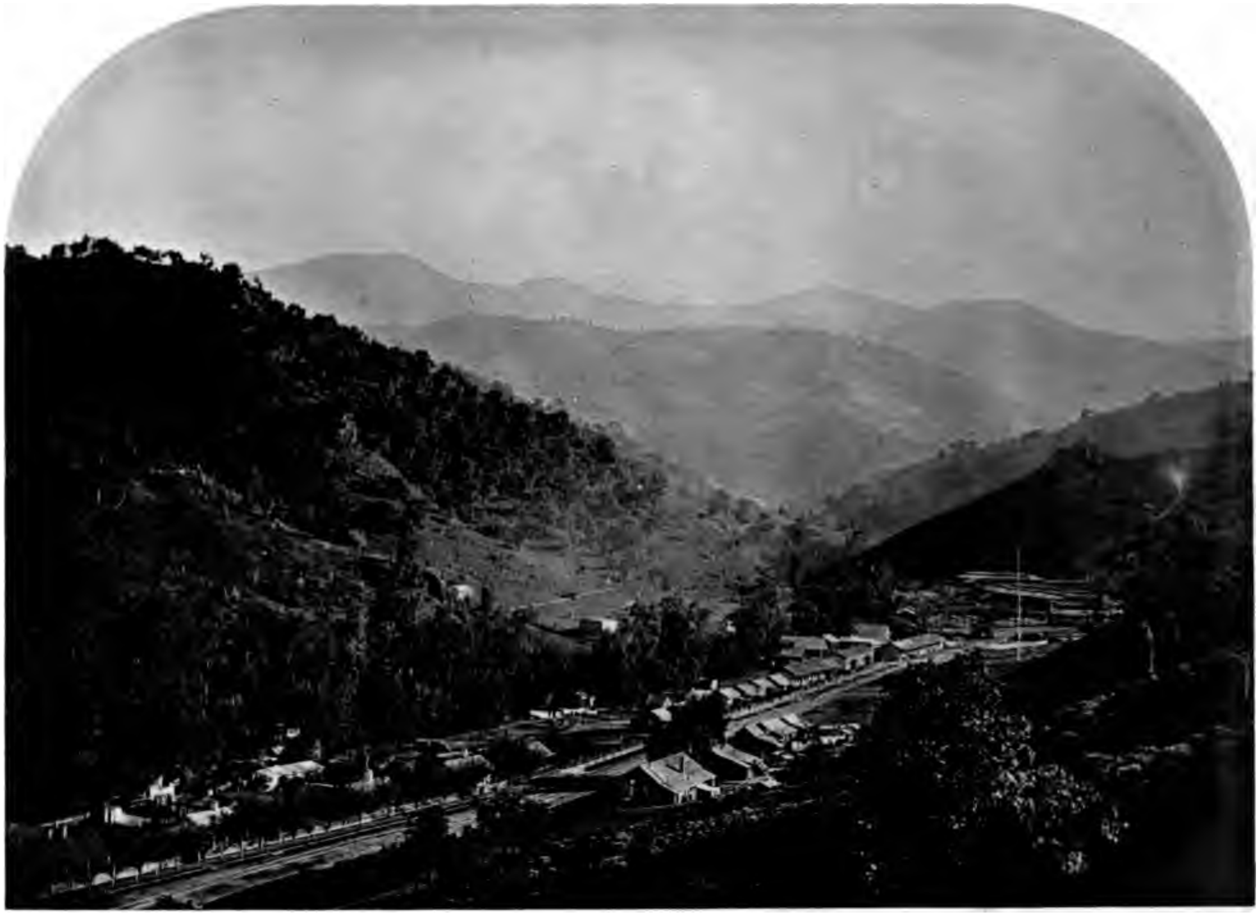

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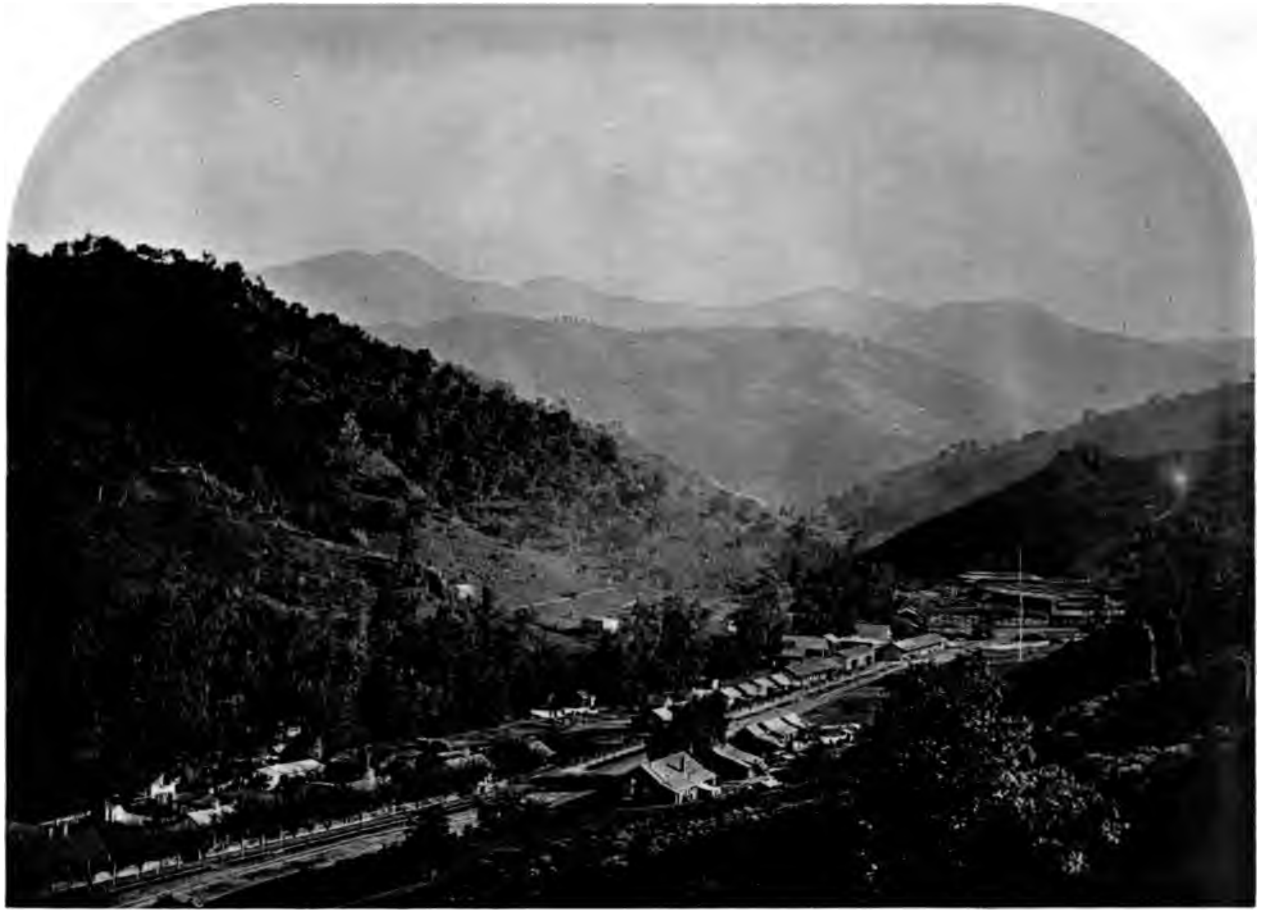

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NEW ALMADEN. THE VILLAGE AND HACIENDA.

J C Branner

(UNIFORM WITH THE PUBLICATIONS OF THE)
GEOLOGICAL SURVEY OF CALIFORNIA.
J. D. WHITNEY, STATE GEOLOGIST.

GEOLOGY.

VOLUME II.

THE COAST RANGES.

APPENDIX.

RARY

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1882.

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1839
CAMBRIDGE, MASS

PREFATORY NOTE.

THE material herewith presented was prepared under my direction during the last two or three years of the continuance of the Geological Survey of California. It was my intention that the investigations here begun should be continued until the Economical Geology of the Coast Ranges had been as completely worked out as was possible, and the whole was to form an Appendix to a volume on the General Geology of the same region.

The difficulty of carrying on a survey without assistance from the State will be admitted, I trust, to be a sufficient apology for the delay in the appearance of the volume in question. It is still my expectation that I shall be able, at no distant time, to take up the Coast Ranges of California, and describe and discuss their geological structure more fully and correctly than was possible at the time of the appearance of Geology, Volume I. (1865). Indeed considerable material preparatory to this work has already been accumulated. The number, character, and style of the volumes* issued since the stoppage of the State Survey by the Legislature will be accepted, I hope, as evidence that I am doing the best I can, under the circumstances, and that I have not been unmindful of what was expected of me when I took charge of this work in 1860.

This Appendix being already in type, I have thought it best to print a few copies for convenient reference, since the appearance of the volume to which it properly belongs must necessarily be delayed for at least a year longer.

J. D. WHITNEY.

CAMBRIDGE, MASS., May 1, 1882.

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* See list of these on the next page.

PUBLICATIONS OF THE GEOLOGICAL SURVEY OF CALIFORNIA.

(Issued since its Stoppage by the Legislature.)

1. THE YOSEMITE GUIDE-BOOK: A Description of the Yosemite Valley and the Adjacent Region of the Sierra Nevada, and of the Big Trees of California. New Edition, revised and corrected. With 4 Maps. 16mo. pp. viii and 186. 1874.

2. CONTRIBUTIONS TO BAROMETRIC HYPSOMETRY. With Tables for Use in California. Royal 8vo. pp. 1–88, 1874; Supplementary Chapter, added in 1878, pp. 89–112.

3. BOTANY, Volume I. Polypetalæ, by William H. Brewer and Sereno Watson; Gamopetalæ, by Asa Gray. Royal 8vo. pp. xx and 628. 1876.

4. BOTANY. Volume II. By Sereno Watson. Royal 8vo. pp. xvi and 559. 1880.

5. REPORT ON THE FOSSIL PLANTS OF THE AURIFEROUS GRAVEL DEPOSITS OF THE SIERRA NEVADA. By Leo Lesquereux. 4to. pp. viii and 62. With 10 Double Plates. 1878.

6. THE AURIFEROUS GRAVELS OF THE SIERRA NEVADA OF CALIFORNIA. 4to. pp. xviii and 569. With 24 Plates and 2 folded and geologically colored Maps, one of which is in two sheets. pp. 1–288, 1879; pp. 289–569, 1880.

7. THE CLIMATIC CHANGES OF LATER GEOLOGICAL TIMES: A Discussion based on Observations made in the Cordilleras of North America. 4to. Part I., pp. 1–120, October, 1880; Part II., pp. 121–264, April, 1882; Part III., completing the work, in press.

Nos. 5, 6, and 7 are issued in quarto form, in connection with the Museum of Comparative Zoölogy at Cambridge; Nos. 5 and 6 form Volume VI. of the Memoirs of that institution; No. 7 forms a part of Volume VII. of the same series. No. 6 is also issued as a separate volume, under the title of "Contributions to American Geology," Vol. I.; and Nos. 5 and 7 form Volume II. of the same. It is expected that "Lithological Studies: A Description and Classification of the Rocks of the Cordilleras," by M. E. Wadsworth, will soon appear as Volume X. of the Memoirs of the Museum, and as Volume III. of the "Contributions to American Geology." Two volumes, continuing and completing the "Ornithology of California," and containing a description of the Water Birds of North America, North of Mexico, are also in a forward stage of preparation.

MAY, 1882.

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E. Chemical Examination of Pacific Coast Coals. By S. F. PECKHAM. I., July, 1872; II., September, 1872. 41–48

F. Examination of the Bituminous Substances occurring in Southern California. By S. F. PECKHAM.

Part I. Geological and Historical. (June, 1866.) 49–73

II. Chemical Investigations.

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G. Report on an Examination of the Quicksilver Mines of California. By W. A. GOODYEAR. (May, 1871.) 91–135

H. Notes on the Geology of Lower California. By WILLIAM M. GABB. 137–148

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APPENDIX.

A.

DETAILED DESCRIPTION OF THE MONTE DIABLO COAL-FIELD.

BY W. A. GOODYEAR.

(APRIL, 1870.)

SINCE the publication of the first volume of the Geology of California this coal-field has been extensively developed, and its present yield of coal amounts to not far from 150,000 tons per annum.

The two villages, Somersville and Nortonville, which have grown up here at the mines, contain, each, a population of three or four hundred miners, besides women and children. These villages are about one mile apart, and separated from each other by a saddle of the hill some 350 feet in height. A railroad has been built from Nortonville to New York Landing, and another one from Somersville to Pittsburg Landing, — these two points of shipment being on the San Joaquin River, near its mouth, and some three miles apart. Each of these railroads is about six miles in length. For the first three miles from the landings they traverse the plain, which slopes gently from the edge of the hills towards the river.

The rise from the river-bank to the edge of the foot-hills on each road is nearly the same, namely, 180 feet, giving an average grade of about sixty feet to the mile over this portion of the roads. For the remainder of the distance to the mines the grades are far heavier, and the roads curve sharply around the sides of the cañons. The Black Diamond Railroad, which runs from Nortonville to New York Landing, has, for a distance of over half a mile, a maximum grade of 293.75 feet to the mile; and the maximum grade of the Pittsburg Railroad, which runs from Somersville to Pittsburg Landing, is not much less than that of the Black Diamond. The cars employed upon the Pittsburg Railroad are built entirely of iron, and hold from five to six tons each. On the Black Diamond Railroad a portion of the cars are built of wood, and a portion of them with sheet-iron sides and wooden bottoms. The latter, called "iron cars," hold about four and a half tons each, and the wooden ones three and a half each. (The "ton" here spoken of is always the gross ton of 2,240 pounds avoirdupois.)

The minimum radius of curvature on the Black Diamond Railroad is 321.25 feet, giving nearly an 18° curve. Locomotives are used to haul the empty cars from the landings up to the mines; but the loaded cars run down to the river by their own weight, their speed being moderated and controlled by the brakes. On the heaviest portion of the grade, when the track is wet, the wheels show a strong tendency to slip, and it sometimes requires close attention on the part of the brakemen to control the loaded train and keep it from running away (indeed, one or two accidents of this kind have occurred), but when the track is dry there is no difficulty.

The locomotives employed here burn the coal from the mines, and weigh from fifteen to eighteen tons, without coal or water.*

The engine "D. O. Mills," on the Black Diamond Road, weighs about fifteen tons when empty. She carries 600 gallons of water in her tank and 700 to 800 in her boiler, and about one ton of coal. She rests on six wheels, each three feet in diameter, all of which are drivers, has ten feet six inches length of wheel-base, has fourteen-inch cylinders with eighteen-inch stroke, and has power enough to slip her wheels on a dry track with 125 pounds of steam. She will haul up the maximum grade a load of from 80,000 to 100,000 pounds.

The trains consist of from twelve to sixteen cars, and carry from sixty to seventy tons each of coal. The average speed of the downward trains is from twelve to fifteen miles per hour.

The most extensive mining developments in this coal-field are comprised between the west side of Sections 5 and 8 and the east side of Sections 4 and 9, — T. 1 N., R. 1 E., Monte Diablo meridian. The general course of the beds here is nearly east and west, and the dip is always to the north. But the irregularities are so numerous, and the variations so great, that they will perhaps be best understood from a description of each of the various mines in succession.

Only two beds are yet proved to be of any value.† The lower one, called in the first volume of the Geology of California the "Peacock Vein," is now universally known as the "Black Diamond Bed." The upper one is known as the "Clark Bed." Between the two there is a thickness, at the Black Diamond Company's mines, of 365 feet of alternating shales and sandstones, including two or three little streaks of coal too thin to be of any value. The thickness of these intervening strata varies more or less at different points, and, indeed, the opinion expressed on page 29 of Geology, Vol. I., "that at no two points on the line of outcrop will the sections of the strata and the included coal-beds be found exactly the same," has proven to be strictly true.

The Black Diamond Company owns the south half of Section 5, on which is situated the village of Nortonville, the north half of Section 8, and the northwest quarter of Section 9.

The Union Company owns the southwest quarter of Section 4, with an additional strip on the east, giving them a total width, east and west, of 3,280 feet.

Next east of the Union lies the Eureka Company, with a width of a little over 1,100 feet.

Adjoining the Eureka is the Pittsburg Company, which owns 160 acres, in the centre of which is the section-corner between Sections 3, 4, 9, and 10.

East of the Pittsburg Company comes the "Central," or "Stewart's Mine," lying partly on Section 3 and partly on Section 10, and extending east as far as the east side of these two sections.

---

* *March, 1871.* A new locomotive which has been placed on the Black Diamond Road within the past year is said to weigh, with water and coal, about 25 tons.

† See farther on in Notes of 1873, for more light on the subject.

The Independent Claim adjoins and overlaps both the Pittsburg and Eureka on the north, lying partly on Section 4 and partly on Section 3.

These are all the mines at which any work is being done at present, though considerable work has been done in the past both at the "Peacock" and the "San Francisco," which adjoin the Black Diamond in order on the west, and also at the "Teutonia" and the "Pacific," the former of which is on the southwest quarter of Section 7, T. 1 N., R. 2 E., and the latter within the limits of the Los Meganos Grant, near the position which would be occupied by the southeast corner of Section 22, T. 1 N., R. 2 E., if the United States section-lines were extended over the grant.

The ground now owned by the Black Diamond Company comprises that formerly owned by the Cumberland, the Black Diamond, the Mount Hope, and the Manhattan.

The Black Diamond Company are working extensively both the Clark and the Black Diamond beds, and it is only within the limits of this company's property that the working of the *Black Diamond Bed* has hitherto proved profitable; all the other mines now worked are on the Clark Bed.*

This company is now working the Black Diamond Bed by means of two separate tunnels, driven southerly from the cañon through the overlying strata to reach the coal. The first of these, called the Clayton Tunnel, starts from the bottom of the cañon, at an altitude of 790 feet above low-water mark in the San Joaquin River (775 feet above the railroad track on the new wharf at New York Landing), and, running southerly a distance of 368 feet, here pierces the Clark Bed, and then continues on 710 feet farther, to the Black Diamond Bed, making its whole length 1,078 feet.

The other tunnel, called the Upper Black Diamond Tunnel, starts from a point between the outcrops of the two beds, a little farther west than the Clayton Tunnel, and higher up the cañon, being about 1,034 feet above low-water mark in the San Joaquin. This tunnel is 422 feet long, and strikes the Black Diamond Bed at a point about 300 feet farther west than the point at which the Clayton Tunnel strikes it. The difference of level is sufficient to give from 460 to 500 feet or more of backs between the two, according to the dip of the bed. From the Upper Tunnel the "Upper Black Diamond Gangway" was driven some 300 or 400 feet easterly and the coal above it worked out. To the west, this gangway had been driven, on January 1, 1870,* a distance of 3,750 feet from the tunnel, and is still advancing. For nearly the whole of this distance the coal has been worked out above this gangway as high towards the croppings as it has proved to be of any value. The height of the backs thus worked has varied with the contour of the hills above from 300 to 600 feet, averaging perhaps between 450 and 500.

All the underground hauling on the gangways is done by horses. The coal from this part of the mine, on issuing from the Upper Tunnel, is dumped into the bunker, from which it is loaded into the railroad cars. These cars, carrying three and a half tons each, are then lowered, two at a time, over an automatic plane 925 feet in length, with an inclination of 14°, down to the level of the railroad tracks below. The plane is supported upon a high trestle-work of timber, built along the rocky side of the cañon. The cost of this structure was very heavy, and it is probable that an underground slope from the upper to the lower gangway on the coal-bed itself would have proved a more economical investment for the owners.*

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* See farther on in Notes of 1873.

From the point where the Clayton Tunnel strikes the bed the "Lower Black Diamond Gangway," on January 1, 1870, was driven east 1,277 feet, and west 2,132 feet, and is still advancing in both directions.*

The Clark Bed is here worked by means of two separate slopes sunk with a southerly pitch through the overlying strata to reach the bed. The higher of these two slopes, called the "little slope," is 98 feet long, has a pitch of 35°, and strikes the Clark Bed at a point 1,073 feet west of the section-line between Sections 4 and 5, and 12 feet lower than the level of the Clayton Tunnel. The lower one, called the Mount Hope Slope, is 293 feet long, measured from the surface of the ground, has a pitch of 37° 15′, and strikes the bed at a point 840 feet west of the line between Sections 4 and 5, and 304 feet lower down, measured on the pitch of the bed, than the foot of the little slope. From the foot of the little slope the "Clark Bed Main Gangway," on January 1, 1870, was driven east to the section-line, passing under the Clayton Tunnel, and west 2,775 feet. And from the foot of the Mount Hope Slope, the "Mount Hope Gangway," at the same date, was driven east to the section-line, and west 1,571 feet.* Below this latter gangway no coal has yet been taken out by this company. But they are now engaged in sinking an underground "slope" on the bed, in order to obtain another "lift" of about 300 feet in height, measured on the dip of the bed. On April 4, 1870, this slope was down about 90 feet. Above the "main gangway," the breasts on this bed have been worked much of the way for a height of 500 feet or more on the dip of the bed towards the croppings.

The dip of the coal-beds in the vicinity of these openings averages 31° to the north; their strike being about N. 85° W., — *true course.*

The average thickness of the Clark Bed here is thirty-three inches, the roof and floor being of sandstone.

The thickness of the Black Diamond Bed varies, but the average thickness of the portion worked has been about forty-three inches. Where the Black Diamond Bed attains its fullest development, its total thickness is from eighteen to twenty feet, of which from four to five feet in the middle of the bed is then good workable coal, — this coal being overlaid and underlaid by from six to eight feet of impure shaly coal, called "bone" by the miners, which contains much earthy matter and is interstratified with streaks of clay slate. Above and below the "bone" the immediate roof and floor of this bed generally consist of clay slate, or more properly of compact clay-rock, which exhibits little tendency to slaty structure, is bluish-gray in color, and rather soft, but tough. This rock, whenever exposed to atmospheric influences on the surface of the ground, disintegrates rapidly, forming clayey mud, although when first laid bare in the mines it generally requires blasting. There are places in the mine, however, where this clay-rock over the bed is wanting, and sandstone forms the roof, as at the Clayton Tunnel. The same may be true of the floor, but it has been rarely exposed.

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* See Notes of 1873.

Of the clay streaks enclosed in the "bone," two are pretty constant features of the bed, being generally seen wherever a section is made. One of these layers is above and the other below the coal. The thickness of the upper one ranges generally from six to ten inches, and that of the lower one from twelve to twenty inches.

The thickness of coal and "bone," between these "top" and "bottom clays," where the coal is good and the bed is worked, ranges from five to eight feet, and sometimes more. Throughout a large portion of the mine there is, immediately above the "top clay," another small layer of pretty good coal, which, however, is never worked. Much of the way this top coal is about a foot in thickness, and above it, as well as below the "bottom clay," there is a considerable thickness of "bone." The bone is generally thin-bedded and very shaly.

The above description of the general character of the Black Diamond Bed holds good from the Clayton Tunnel westerly as far as the works of the Black Diamond Company have yet extended, i. e. for a distance of 4,200 or 4,300 feet. But as we go east from the Clayton Tunnel along the Lower Black Diamond Gangway the thickness of the good coal rapidly diminishes, and within a distance of two or three hundred feet the layer becomes so thin that it will not pay to work; and east of this point but little coal has ever yet been taken from any portion of the Black Diamond Bed, though much work has been done in the way of exploration. The bed itself, however, though thinner and consisting chiefly of "bone," nevertheless continues its course, and may be traced, certainly as far east as the "Central," and probably even to the Pacific Mine.

As the coal disappears in going east from the Clayton Tunnel, the "top" and "bottom clays" increase in thickness, while the space between them contracts to three feet or less, and contains only "bone." For several hundred feet here the gangway is driven along just under the "top clay," which is left to form its roof. At a point about 800 feet east from the tunnel the gangway passes under a deep cañon, and then enters beneath the high and massive hill in which was situated the old "Manhattan" mine. At the same time the dip of the bed begins to diminish. At the distance of 1,113 feet from the tunnel, a large fault crosses the gangway very obliquely, running northeast and southwest. This fault is an upward jump to the east of some thirty or forty feet. For about a hundred feet, easterly from its line of fracture, the gangway is driven through the tough clay rock which underlies the bed, no carbonaceous matter being in sight until the "bone" again makes its appearance coming in from the roof. East of this fault the bed lies much flatter, dipping only 24°. Its thickness, however, again increases somewhat, and the face of this gangway, in April, 1870, showed a thickness of about two feet of tolerably good though rather soft coal.

The Clayton Tunnel crosses the line of strike very nearly at right angles, and the section of the strata exhibited by it is as follows.

Starting from the roof of the "bone" at the Black Diamond Bed and travelling northerly towards the mouth of the tunnel, and measuring the distances horizontally (remembering, however, that the strata dip 31° to the north), we have in order as follows: —

	Feet
Sand-rock, heavy-bedded, and dry	66
Sand-rock, also heavy-bedded, but wet	40
Thin-bedded and ferruginous sandstone	4
Sand-rock, heavy-bedded, and wet	31
Thin-bedded carbonaceous shale, dry	10
Alternations of sand-rock and shale, some of the latter carbonaceous, dry	35
Sand-rock, heavy-bedded, dry	20
Alternations of sandstone and shale, the latter here and there carbonaceous, wet	25
Same alternations, but dry	46
A streak of Coal from four to six inches thick.	
Alternations of shale and sandstone, dry	139
Heavy-bedded sand-rock, dry	50
A seam of Coal ten or twelve inches thick, with about five or six inches of bone on each side.	
Heavy-bedded sand-rock, dry	148
A bed of Carbonaceous Shale one foot thick.	
Heavy-bedded sand-rock	18
Another bed of Carbonaceous Shale about a foot thick.	
Coarse-grained sand-rock, generally heavy-bedded and underlying the Clark Bed	about 50
THE CLARK BED OF COAL.	
Heavy-bedded sand-rock overlying the Clark Bed and similar to that below it	148
Bluish clay-rock, moderately heavy-bedded, with occasional bands of sandstone a few inches thick	127
Chiefly very thin-bedded shales, reaching to the mouth of the tunnel	93

In the Upper Black Diamond Tunnel two small seams of coal are also cut through above the Black Diamond Bed. But their distances from this bed and from each other are different from those of the two seams which are cut between the Black Diamond and the Clark beds in the Clayton Tunnel. They are about seventy-four feet apart, and the lower one is about 200 feet from the roof of the Black Diamond Bed, the distances being measured horizontally. The upper one of these seams is here fourteen inches thick.

In going towards the west from the Upper Black Diamond Tunnel, the Black Diamond Bed is unbroken for a distance of 800 feet along the gangway. At this point a fault crosses the gangway, running N.E. and S.W., and making a jump of ten or twelve feet down to the west. At a point 181 feet beyond this another fault, nearly parallel to the first, makes a second jump down to the west about equal in amount to the first one. At the distance of 2,550 feet from the tunnel another fault, running N.E. and S.W., makes a jump of two feet up to the west. About 150 feet beyond this another fault crosses the gangway, running N. W. and S.E., and making a jump of five or six feet down to the west. The last two faults intersect and cross each other in the breasts a short distance above the gangway.

These are all the notable faults along this gangway, which is now (April, 1870) not far from 3,900 feet in length. But, little broken as this portion of the Black Diamond Bed is by faults, there is, nevertheless, a great change in the direction of its strike and a considerable change in its dip within this distance. The gangway follows of course very nearly the line of strike of the bed. And though it is more or less crooked all the way, yet when viewed as a whole, in going westerly from the tunnel, it gradually curves with a long and remarkably regular sweep towards the south, while at the same time the dip diminishes, or, as the miners say, "the coal lies flatter."

The "true course" of the gangway near the upper tunnel is about N. 80° W., and the dip 30°; while near its western extremity S. 55° W. may be assumed as about its average course, and the dip is about 25° to the N.W. So that within a little less than three fourths of a mile the line of strike of this bed describes an almost circular arc of about 45°. And at the western extremity of this curve the course of the bed is such, that, if prolonged towards the southwest, it would pass considerably east of even the "Peacock" Mine, while it would leave the "San Francisco" nearly half a mile northwest of it. Yet the "Peacock" Mine is unquestionably on the same bed, and probably the "San Francisco" too.

The lower gangway on this bed has not yet advanced far enough westward to show this curve so plainly as the upper one; nor, indeed, can it do so within an equal distance; for, being some 230 feet vertically lower than that, and conforming to the conoidal surface with the decreasing dip of this portion of the bed, it must describe an arc of larger radius, which radius also increases as the dip diminishes. The length of the upper gangway being already about 3,900 feet, it has only a little over 400 feet more to go on this course before reaching the western section-line.

The level of the "Main Gangway" on the Clark Bed is, it will be remembered, but a few feet lower than that of the lower gangway on the Black Diamond Bed. Both these gangways are rapidly advancing westward. But the "Clark Bed Main Gangway" is some 800 feet in advance of the "Lower Black Diamond" in this direction. Up to the points which were reached, however, at the date of the last survey which has hitherto been made of these gangways (July, 1869), the Clark Bed showed as yet no decided indications of curving to the south,* though the Lower Black Diamond Gangway had already begun to curve, while at a point in the Upper Black Diamond Gangway, as far west as the face of the Clark Bed Main Gangway at that date, the curvature of the Black Diamond Bed was already very marked. The dip of the Clark Bed, however, had already diminished from 31° at the "Hoisting Slope" to about 28°, and the level distance between the beds, which at the Clayton Tunnel is 710 feet, was here very noticeably greater and still increasing; the latter fact being a necessary consequence of the diminished dip of the beds.

A single large fault crosses the Clark Bed Main Gangway in a N.E. and S.W.

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* See Notes of 1873.

direction, at a point about 570 feet west of the hoisting slope, producing a jump of perhaps fifteen or twenty feet down to the west. The position and course of this fault through the strata are such that it may perhaps be connected with one or the other, possibly with both, of the two large jumps already noticed, which are seen in both the upper and the lower gangways on the Black Diamond Bed, though this is uncertain. East of this point, however, there are no faults in the Clark Bed within the limits of the Black Diamond Company's ground. Indeed, no other fault occurs in this direction until we reach a point from 500 to 600 feet within the Union Company's ground, giving us here a total distance of over 2,100 feet, which is by far the longest stretch yet found, or likely to be found, on either of these beds entirely free from faults. For a considerable distance also to the west from this large fault no other breaks of consequence occur. But at a point about 2,100 feet westerly from the hoisting slope there begins a curious disturbance, which extends from here onward over a distance of not less than 700 feet along the gangway. Throughout this whole distance the Clark Bed is broken by a constant succession of little faults or "jumps," of which there are probably more than fifty to be seen along the gangway within the distance named. These jumps vary in amount from one or two inches to four or five feet. Some of them are up, and some of them are down to the west, and some of them run N.E. and S.W., and others N.W. and S.E. In short, they run in all directions, breaking up the bed into little polygonal pieces. Moreover, they change in character as they run up the dip of the bed. For example, a fault which appears on the gangway as a jump of two feet down to the west may diminish as it runs up the breasts and finally disappear, or, the edges of the fissure crossing each other like a pair of shears, it may continue on, and the same fault, a little higher up in the breasts, appear as an upward jump to the west; or the reverse may happen. And so the little pieces into which the bed is broken are more or less irregularly twisted in position, thus increasing considerably the expense of working, while the coal itself is also badly crushed, and crumbles easily.

But, in spite of all this disturbance, no great displacement has occurred at any point here, and the coal, such as it is, maintains its average thickness. And so nearly all this ground is worked, and made to yield what coal it can.

There is no disturbance at all comparable with this upon the adjacent portion of the Black Diamond Bed; and what is the condition of things in this respect with the Clark Bed farther to the west remains to be seen, though for the last hundred feet or more the Main Gangway is now once more free from faults and in comparatively good hard coal. Beyond the point which was reached by the last survey of this gangway, the Clark Bed undoubtedly curves to the south in going west, like the Black Diamond, although with a larger sweep. This is rendered more than probable, not only by the general conformity of the strata throughout this region, but also by the probable outcrop of the Clark Bed itself, which can be traced with considerable approximation to certainty around the southern brow of the hill nearly as far west as the Peacock Mine; the outcrop of the Black Diamond Bed being now traceable, with the aid of the underground explorations, with almost absolute certainty directly to the Peacock Mine itself.

The line of the latter outcrop intersects the old road from the Cumberland House to the Peacock Mine, at a point almost exactly at the summit of the highest saddle of the hill between these two localities. From hence towards the west it bears obliquely down the steep southern slope of the hill, till it reaches the bottom of the gulch at a point not far from where the latter crosses the line between Sections 7 and 8. It then follows very nearly the bed of the gulch, which runs nearly straight all the way to the Peacock Mine. On the southern slope of the hill, at a point one or two hundred feet westerly from the summit of the saddle referred to, an opening once made upon the bed is now abandoned and nearly forgotten. From the surface of the hill a level tunnel was first driven northerly for a few feet, so as to strike the bed a little below the outcrop, and from this point a slope, going down upon the bed somewhat obliquely to its dip, was sunk a little over 150 feet. The bottom of this slope is still accessible, and at this point the coal, though soft, has a thickness of four feet three inches, with "bone," probably of considerable thickness, both above and below it. The strike of the bed here is about S. 60° W., true course, and its dip 28°. The Upper Black Diamond Gangway, which is coming in below here, must already have reached a point which is nearly if not quite as far west as the position of this old slope, and the latter may yet come conveniently in play again as a means of ventilation for the mine below. In going westerly from this point no indication was discovered of any marked change, either in the dip or strike, till a point was reached some six or seven hundred feet west of the section-line. At this point a little vertical shaft has been sunk in the bed of the gulch. We could not go down this shaft; but, as nearly as could be judged by looking in from the top, the strike appears here to be about the same as before, viz. S. 60° W.; but the dip appears to be from 35° to 40°. About 150 feet west of this is the mouth of the old "Peacock Slope." No work has been done at the Peacock Mine for several years, and the lower portion of this slope is now caved and inaccessible. The upper portion of it, however, goes down, obliquely to the dip and strike of the strata, in a direction about N. 65° E., with a pitch of 32°, and shows the strike of the rocks to be nearly due E. and W., and their dip 45°. About eight or nine hundred feet farther west is the mouth of the old tunnel or gangway which was once driven in upon the bed far enough to connect with this slope, but is now closed and inaccessible.

A great change, therefore, occurs both in the dip and strike of the strata within a distance of from 300 to 400 feet to the east from the "Peacock Slope." Within this short distance the great curve, which the Black Diamond Bed has described to the south in coming west from Nortonville, is completely reversed, the strike coming back to approximate parallelism with what it is at Nortonville, while the beds are tilted up at a far greater angle of dip. So great a change within so short a distance indicates a strong probability, not simply of curvature here, but of much fracture and dislocation. In the Peacock Tunnel, although the general strike of the bed continued about the same, yet, if we are correctly informed, it was badly faulted and the coal was poor. With reference to the quality of the coal here, however, it should be noted, that this tunnel nowhere attained a sufficient depth below the croppings to prove that it may not be better below.

On both the Clark and the Black Diamond beds it is rare that the coal is good very close to the croppings, while it is sometimes poor to the depth of one or two hundred feet, in places where it is good below. But where the beds are much broken the coal is apt to be crushed and soft.

In going west from the Peacock, the evidences of disturbance do not diminish till we reach the San Francisco Mine. For example, the road from Nortonville to Clayton, after crossing the high saddle on the north, follows down the cañon between these two mines, and at one point where the strata are exposed in the bottom of the gulch alongside the road, they are seen to strike about N. 5° W., and to dip very steeply to the east.

The San Francisco Mine is about half a mile to the west of the mouth of the Peacock Tunnel. It is on the northwest quarter of Section 7, and is situated in a cañon from 300 to 400 feet lower than the crest of the high hill which rises to the north. A slope going down here on the bed is said to have been sunk to the depth of about 300 feet; but the lower part of it is now full of water. The only gangway which is now accessible starts from a depth of about 160 feet.

The pitch of the slope, which is the same as the dip of the bed, is 41° near the top; but it grows steeper as it descends, and at the level of the gangway the dip is 50°.

The gangway is driven about 275 feet towards the east, the dip at its face being 65°, and the strike S. 85° W. This gangway is also said to have been driven about 75 feet west from the slope. Faults are very numerous, and the coal is soft and poor. In the face of the east gangway it is two feet thick. The roof and floor of the bed are clay-rock. Below the bed, and separated from it by about six feet of clay-rock, is another layer of coal about one foot thick. There is also said to be another little seam of coal above the bed and similarly separated from it by a few feet of clay-rock. No "bone" was seen here.

The question arises, Upon what bed is the San Francisco Mine located? Is it the Clark Bed, or the Black Diamond, or one of the seams between the two, or some other? The course from its mouth to the mouth of the Peacock Tunnel is S. 76° E. This would place the San Francisco Mine somewhat too far to the north for it to be on the prolongation of the general line of strike of the Peacock. But then the mouth of the San Francisco is probably 75 feet lower than that of the Peacock, and the dip at the mouth of the San Francisco slope is only 41°. If this dip were produced upwards, perhaps diminishing still more as it rises (a supposition not at all improbable), to the level of the Peacock Tunnel, it would bring the San Francisco considerably nearer to the line of strike of the former. But, on the other hand, though it is certain that the Peacock is on the Black Diamond Bed, there is no certainty that this bed holds its course with any continuity across the sag under the Clayton road between the two, but every probability that there is much disturbance here. If we consider the apparent character of the bed itself, it differs largely from either the Clark Bed or the Black Diamond wherever these are worked elsewhere. It has not the "bone" which almost universally accompanies the latter, nor has it the sandstone roof or floor of the former. So far, however, as it resembles either, it is more like the Black Diamond than it is like the Clark Bed.

Its heavy clay-rock roof and floor, with the accompanying little seams of coal, may possibly correspond to the "top" and "bottom clay" of the Black Diamond Bed, with its "bone" above and below. It does not resemble either of the seams seen elsewhere between these two beds. There are one or two other facts which would seem to point to at least a possibility, if not to a considerable probability, that this mine may be on the Black Diamond Bed. On the steep southern slope of the hill just north of the mine some little openings have been made, and one or two little seams of coal of no value have been discovered. These may be the seams seen elsewhere between the two beds. Again, though the dip is so high at the San Francisco Mine, being 65° in the face of the gangway, yet on the crest of the hill northeast of the mine and west of the Clayton road the strata seem to lie more nearly horizontal, and dip to the north at only a moderate angle. Furthermore, a heavy bed of sand-rock, similar to that which elsewhere accompanies the Clark Bed, may be traced continuously around the summit of this hill, then over the crest and down the northern slope of the ridge to the bottom of another cañon, for a distance of a quarter of a mile or more to the northwest. And near the bottom of this cañon a tunnel has been driven in 160 or 170 feet, which shows at its face, in this sandstone, a bed of impure coal eighteen inches thick, which strikes nearly due E. and W. and dips only 24° to the north. It is not impossible that this may be the Clark Bed itself, though the locality at which it is here found must be about one third of a mile nearly due north from the San Francisco, and it dips only 24°, while the dip at the San Francisco is 50° to 65°. This locality is on the southwest quarter of Section 6, about five or six hundred feet east of the Monte Diablo meridian line, and is known as "The Frenchman's Claim." A short distance to the east from the tunnel a slope was also sunk some eighty or a hundred feet on a bed of shale which accompanies the sandstone, but no coal was found here. The strike of the shale at this point is about S. 75° W., and its dip 24°. Another slope was also sunk in the bottom of the cañon; but this is now caved in.

To the west of the meridian line no further explorations have yet been made by the Geological Survey.

At the San Francisco Mine there is a little steam-engine with hoisting arrangements, and a small Stoddard's pump. At present (April, 1870) they are just keeping the water out of the mine, but doing no further work.

The line of outcrop, both of the Clark and the Black Diamond beds, is exceedingly irregular; for it depends not only upon the course of the beds themselves, but also upon the topography of the surface, which within the mining limits is very rough.

The northwest quarter of Section 9 belonged originally to the old Manhattan Company, who did considerable work before they sold it to the present owners. They drove in from the gulch at Somersville a long gangway towards the west on the Clark Bed above the Union Company's works, and took from here a large quantity of coal. From this gangway they also drove a tunnel to the Black Diamond Bed, and then drove a long gangway to the west on that bed. These old works are now inaccessible. But it is said that when they quit work they had on the Black Diamond Bed from three to four feet of good coal. If we are correctly informed, however, they never extracted much coal from this bed. It is also stated that in these works both the Clark and the Black Diamond beds "lie very flat." It has been already noted that at the eastern extremity of the Lower Black Diamond Gangway the dip is only 24°. It is also a fact that in the adjacent portion of the Clark Bed, in the western part of the Union Mine, the dip is somewhat less than it is to the east or to the west, being here about 27° or 28°. Now the great mass of the hill, which covers nearly half the area, including all the mining ground, of the northwest quarter of Section 9, is triangular in its general form, the apex of the triangle which forms the summit of the hill projecting far to the south and rising to an altitude of nearly 1,500 feet above low-water in the San Joaquin. And on the surface of the ground in this hill towards its summit the strata are seen to dip considerably less than they do in the other hills adjacent. The exact dip here was not measured, but it looks from a distance as if it could not exceed 20°.

In this hill, therefore, the strata are curved in the direction of the dip, and from a certain level the dip diminishes from below upwards. The effect is such a one as would have been produced if the upper portion of the hill had been inadequately supported beneath, and the strata, being slightly plastic, had gradually bent with their own weight, the apex of the hill settling the most. It is probably owing to the fact that some of the earliest mining operations here were in this hill, that the statement has been so generally made, and is even yet current with respect to the Monte Diablo mines, that "the dip of the coal increases with its depth." There is no evidence whatever of the truth of this statement as a general fact, nor does the structure of the country render such a state of things likely. It is a local fact, which holds true within certain limits in this hill, and which, owing to the irregularities of the strata, may be true, here and there, to a limited extent elsewhere. But it is not true of the beds in general.

In going east from the "Mt. Hope Slope" of the Black Diamond Company towards the Union line, the Clark Bed gradually diminishes somewhat in thickness, and, for several hundred feet east of the section-line in the Union ground, its average thickness does not exceed two feet.

The companies now working at Somersville are the Union, the Eureka, and the Pittsburg. They are all of them working the Clark Bed only, and each of them reaches the bed by means of a slope sunk through the overlying strata with a pitch reverse to the dip of the coal, i. e. these slopes descend to the south. From the various levels at which they thus first strike the coal, each of the companies has also sunk a "counter-slope," i. e. an underground hoisting slope going down on the dip of the bed itself. Each of these counter-slopes is worked by an underground steam hoisting engine placed at its head and worked by steam which is conducted into the mine in iron pipes from the boilers at the surface. This engine is connected by the necessary gearing with the drum or spool which carries the round or flat wire rope employed to haul the loaded cars up the slope; and thus the coal is worked out from greater depths. The pumping, where required in these slopes, is done by "Stoddard's Double-acting Steam-Pumps." The same arrangement is employed for the counter-slope which is now being sunk from the Mt. Hope Gangway in the Black Diamond Company's mines.

The mouth of the Union Mine is 866 feet above the level of low-water in the San Joaquin, and is but a short distance west of the east line of the southwest quarter of Section 4. From this point the surface slope runs down to strike the bed. This slope is furnished with but a single track. Its length is a little over 400 feet, and its pitch about 37°. From the foot of this slope, where it strikes the bed, a gangway runs east and west the whole length of the claim (i. e. about 3,300 feet), and above this gangway all the coal has been worked out up to the old Manhattan Gangway, a height of from 500 to 600 feet as measured on the dip of the bed. On this gangway, at a point 200 feet west of the foot of the surface slope, is the head of the counter-slope, the length of which down to the next lower gangway, the present lowest gangway in the mine, is said to be 288 feet, and its pitch, which is of course equal to the dip of the bed at this point, to be 30°. It is furnished with a double track. This lower gangway also has been driven east to the boundary of the claim, and west to within some 300 or 400 feet of the Black Diamond Company's line, and all the coal above it is worked out excepting the little piece thus left at the western end. At a point 230 feet east of the foot of the surface slope another counter-slope goes down to the lower gangway, and has recently been sunk about 300 feet farther still. From the point thus reached another gangway will be driven, and thus another "lift" of about 300 feet of coal obtained. The total depth from which this coal will have to be hoisted and the water pumped will then be nearly 600 feet on the counter-slope and 428 feet on the surface slope, making a distance of a little over 1,000 feet, with a total vertical lift of about 550.

There is considerable water in this mine, and the two pumps employed have one of them an 8-inch and the other a 10-inch cylinder, both having a stroke of thirty-six inches. And yet the new counter-slope, though sunk 300 feet below the lowest gangway, is almost perfectly dry. Nor is it likely that any water of consequence will be found in drifting east from here. The water in this mine comes from the west, and most of it comes from the line of a certain fault which appears to furnish the channel for a considerable and constant stream.

In noting the yet undescribed accidents of the bed in the grounds of this company, we may take the gangway which runs at the foot of the surface slope, and, beginning at the Black Diamond Company's line, travel eastward through the mine. At the distance of 580 feet from our starting-point we then meet a fault which presents a jump of thirty feet down to the east. At 350 feet beyond this another fault crosses the gangway, showing a jump of fifty feet up to the east. At a distance of 750 feet farther east we find three successive jumps close together, the first being four feet down to the east, then four feet up to the east, then twelve feet down to the east. At a point 700 feet east from the last of these, and about 100 feet west from the surface slope, is another large fault jumping sixty-four feet up to the east. All these faults run N.E. and S.W. East of the surface slope, and between it and the Eureka line, the gangway crosses another fault, which appears here as a small jump of eighteen inches up to the east. It runs N.E. and S.W., but does not cross the gangway very obliquely. Its line of fracture, however, is not straight. It curves towards the west in ascending from the gangway, while at the same time the magnitude of the jump increases, and in the upper part of the mine it appears as a jump of sixteen feet up to the east, running very obliquely to the strike. The dip of the bed, which in the western part of this mine has been already stated to be 27° or 28°, increases again on going farther east, and, in the vicinity of the surface slope, attains again its average of 31° to 32°, which it then preserves unchanged through Somersville as far east as the eastern part of the Pittsburg ground. The thickness of the coal also slowly increases with the dip in going east towards the slope, in the vicinity of which it is thirty to thirty-four inches. Throughout the ground of the Black Diamond Company, and in the Union ground as far east as the slope, the immediate roof and floor of the Clark Bed, as already stated, are uniformly sandstone. No "bone" is to be seen. The bed at any point is almost always very nearly uniform in quality throughout its thickness from roof to floor, and, excepting near the outcrop or where it has been crushed by the movements of the strata, consists of good clean coal. Indeed, the absence of "bone" and the uniform quality of the coal throughout the thickness of the bed at any given point are perhaps the two most persistent characteristics of the Clark Bed, wherever it has been identified throughout this whole region. But a little east of the Union Slope a change takes place in the character of the roof. A layer of clay-slate, similar to that which accompanies the Black Diamond Bed, here makes its appearance immediately over the coal, between it and the sandstone. From here eastward this layer of clay-slate continues, varying in thickness from six inches to two or three feet, through all the Somersville mines as far as the eastern part of the Pittsburg, and is again to be seen in Stewart's Mine still farther east. The western edge of this clay-slate roof is somewhat irregular in outline, but it follows through the Union Mine a general course of N.W. and S.E., and therefore gains to the west in going down. At certain points east of here a few inches of clay-slate may also be seen, here and there, under the coal. Sometimes, also, the layer in the roof is wanting, and the sandstone, in places, rests upon the coal. But the general rule, all through Somersville, is a clay-slate roof and a sandstone floor.

Simultaneously with the appearance of this clay-slate roof in the Union Mine a remarkable change also occurs in the thickness of the coal itself, which at once increases from thirty or thirty-one inches to a little more than three feet, the average thickness in the eastern part of the Union Mine being thirty-eight or thirty-nine inches. This thickness then continues about the same through the Eureka ground, but is a little greater still in the Pittsburg, the general average here being not less than three and a half feet, while considerable portions of the mine show an average of four feet, and in places there are four and a half feet of good solid coal.

The slope by which access is gained to the Eureka Mine is prolonged upwards a few feet beyond the surface of the ground to the top of a trestle, whence the cars as they come from the mine are dumped into the bunker. The top of this trestle is 786.5 feet above low-water mark in the San Joaquin. The length of the slope from the top of this trestle to the coal is said to be 290 feet, and its average pitch 43° 15′. It is furnished with a three-rail track with a turnout in the middle to allow the cars to pass, the empty car descending on one side of the slope as the loaded one comes up on the other. The foot of this slope where it strikes the coal is about

168 feet west of the Pittsburg line. At a point 55 feet west from here on the same level is the head of the counter-slope, which is furnished with a double track, and goes down on the bed 330 feet to the level of the lowest gangway yet driven in the mine. Above the level of this gangway all the coal on this bed in the Eureka Company's ground, with the exception of a little piece high up in the hill near the croppings, has already been worked out, the total height of the workings being from 900 to 1,000 feet, as measured on the dip of the bed up towards the outcrop. Below the lowest gangway the company are now going down for another "lift" of coal, and the counter-slope is already sunk about 200 feet below it. They will continue to sink until they discover the locality and height of the old workings of the Independent Company, which lie below.*

The works of the Eureka, as well as of the Independent Company, have been not very well managed in some respects in the past, and the underground condition of things in the Eureka Mine to-day is not as good as it is in some of the other mines. West of the slope, and between it and the Union line, there are said to be several faults in the bed; but all this part of the mine is now inaccessible, and no detailed information could be obtained about them. East of the slope a large fault running N.E. and S.W., and said to be a jump of about eighty feet up to the east, crosses the line between the Pittsburg and the Eureka companies in such a way that it intersects the gangway which runs from the foot of the surface slope of the Eureka at a point about six feet west of the line, and the lower gangway of the Eureka at a point 129 feet east of the line. This is the only fault of which any definite information could be obtained here at the time of our last visit.

The Eureka Company has also driven a tunnel to the Black Diamond Bed. This tunnel starts from the lower gangway at a point 130 feet east from the counter-slope, and is said to be 580 feet long. But this is not the proper level distance between the two beds here; because the tunnel pierces the plane of the large fault already described as coming in from the Pittsburg ground. And this fault, being a large upward jump to the east, of course throws this portion of the Black Diamond Bed nearer to the Clark Bed than it would otherwise be, and shortens the length of the tunnel considerably. It is probable that the true distance between the beds here does not vary much from what it is at the Clayton Tunnel, which is a mile farther west. From the point at which the tunnel struck the Black Diamond Bed a gangway was driven about 190 feet west to the fault, then through the fault and some two or three hundred feet farther to the west. These works are now inaccessible. Mr. Carlyle, the present superintendent of the Eureka, thinks that when the company stopped work here, they had in the face of the gangway about two feet of good coal. But this is hearsay. He says, however, that in the tunnel he saw a bed of impure coal, about four and a half feet thick, very soft, and about 200 feet north of the Black Diamond Bed. About 100 feet north of this were two little seams of good coal, each about three inches thick, and about a foot apart. About 150 feet still farther north is a seam of good coal about eighteen inches thick. A good deal of water comes from this tunnel, the greater portion of it from the thick seam of soft impure coal next north of the Black Diamond Bed.

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* See Notes of 1873.

The property of the Independent Company, as already stated, adjoins the Eureka on the north and overlaps the Pittsburg also in the same direction. The coal beneath it, of course, lies deep. A vertical shaft has been sunk here to reach the coal, its mouth being 719 feet above low-water in the San Joaquin. Some of the engineering in connection with this shaft was of a character more amusing to outside parties than to the owners of the mine. For example, it is said that when the work was commenced, it was expected that the coal would be struck at a depth of from 300 to 400 feet. They sunk 710 feet, and then, leaving sufficient depth for a sump at the bottom, started from a point 686 feet below the surface, and drove a level tunnel to the coal-bed. And, if the statements which are made of the length of this tunnel be correct, the shaft has yet about 200 feet to go before it will reach the coal.

Yet the dip of the bed is perfectly regular, and the depth at which a shaft would strike the coal, its position on the surface being given, was only a question of a little careful surface-measurement and a little calculation. Moreover, they had trouble with water, inadequate capacity of pumps, bad foundation for the engine, etc. And they used the water from the mine for the boilers, which, when subjected to such treatment, would last but a very short time. But having at last reached the coal by means of the tunnel from the bottom, they opened a gangway and began to take out coal.

They worked here some time and took out considerable coal. But no reliable record is left now of the extent of the workings in any direction. The lower part of the shaft and all these works have now been full of water for several years, — indeed, ever since the Independent Company* stopped work.

But, before they stopped, a shoot had been driven up through to connect with the works of the Eureka Mine above for the sake of ventilation, and, though full of water, the connection still remains, and the Eureka Company are now pumping at the Independent Shaft to clear the lower part of their mine from water.

The mouth of the Pittsburg Slope is 838.5 feet above low-water in the San Joaquin. It is said to be 268 feet long, with a pitch of 26° 15′. Thirty feet west of its foot is the head of the counter-slope, which goes down 305 feet on the coal to the present lowest gangway in the mine, and, below this, has just been sunk 300 feet farther for another "lift." From the foot of the surface slope a gangway has been driven west to the Eureka line, and east some 1,800 feet to about the east line of the Pittsburg Claim. Above this gangway all the coal has been worked out as far as it extends, except a small piece in the hill not far from the croppings and near the Eureka line. The maximum height of the works above this gangway is about 650 feet on the dip of the bed.

West of the surface slope there are no noticeable faults except the large one already described near the Eureka line. East of the slope, so far as the works extend, there is only one notable fault, a large one, running N.E. and S.W., showing a jump, estimated at seventy feet, up to the east. This fault crosses the gangway at a distance of 910 feet east from the slope. The lower gangway strikes the same fault at a distance of 1,120 feet from the counter-slope. This lower gangway is driven west to the Eureka line, and east only as far as the fault; and all the coal above it is out as far as it goes. At the bottom of the counter-slope, 300 feet below this gangway, the floor of the bed is sandstone and the roof clay-slate. The dip is 31°, and the thickness is four feet of good hard coal. But a little higher up, and for a considerable distance on this slope below the lower gangway, the coal is four and a half feet thick.

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* *Query.* — Independent of scientific management? — (J. D. W.)

The average course of the gangway from the foot of the surface slope easterly to the large fault is about S. 70° E., true course. But it must be remembered that between these large faults the apparent direction of strike of the beds is influenced by the amount of throw of the faults.

East of the large fault on this gangway the coal is not quite so thick, the course of the strike seems to bend still more to the south, and the dip gradually diminishes, the course near the face being about S. 57° E., and the dip at the face being only 22°. The face of this gangway is the most easterly point in the Somersville mines, and there are no openings of any importance between here and Stewart's Mine, which is half a mile or more to the east of this.

When work was first commenced at Stewart's Mine, a slope was sunk towards the south from above the coal, on the southern part of Section 3, in a cañon on the north side of a high ridge in which the coal crops out, the crest of which ridge runs a little south of east from the Pittsburg Claim nearly on the line between Sections 3 and 10.

If we are correctly informed, however, no coal was ever taken out here. Afterwards it was decided to attack the beds from the other side, and a point was chosen in a steep gulch on the south side of the ridge, about 500 feet below its summit and perhaps 100 feet or more above the bottom of the valley to the south. From this point, below the outcrop of the beds, a level tunnel was driven in towards the north a distance of about 1,030 feet to the Clark Bed, cutting, in its way, all the other beds, none of which, however, are of any value here so far as seen. From the point at which this tunnel strikes the Clark Bed a gangway has been driven about 275 feet towards the east and 375 feet west. On the west side of the tunnel the coal has been worked out above the gangway to a maximum height of about 450 feet, the total distance on the dip of the bed from the gangway up to the outcrop in the brow of the hill being a little over 700 feet. The strike of the bed along this gangway is not far from S. 50° E., and the dip 28° to 29°. The thickness of the coal averages about thirty-eight inches. It has the clay-slate roof and sandstone floor which accompany it at Somersville.

A few feet west of where the tunnel strikes the bed a large fault crosses the gangway, running very obliquely, N.W. and S.E., and making a jump of about eighteen feet up to the west. Beyond this point towards the west no more faults have yet been struck, and it is this portion of the bed which has furnished nearly all the coal this mine has yielded.

East of the tunnel, for the whole distance to which the gangway has yet been driven, the bed is crushed and broken by a constant series of little irregular faults, precisely similar to those already described in the western part of the Black Diamond Company's mines at Nortonville, and the coal is very friable. The coal from the western part of the mine, though bright and pretty clean, is not so good as that which comes from the same bed in the mines of Somersville and Nortonville, — i. e. it is more friable and not so hard. For a considerable length of time this mine has furnished about 1,000 tons per month of coal, which is hauled by teams to Antioch for shipment. The whole length of the tunnel and all the works connected with it are on the northeast quarter of Section 10.

Starting from the point where the tunnel strikes the Clark Bed and travelling southerly along the tunnel towards its mouth, noting the level distances, we find at the distance of about 130 feet a bed of soft and impure coal eighteen inches thick. About 160 feet farther south is another seam of the same material twenty-two inches thick; 70 feet beyond this there is another one nineteen inches thick; and 120 feet farther south is another one, which is supposed to represent the Black Diamond Bed. A gangway was once driven some distance on this seam, and the eastern portion of it, though in a very shaky condition, can still be crawled into for a short distance. This is probably, indeed, the representative of the Black Diamond Bed at this point, though there seems to be little about it that resembles the appearance of that bed elsewhere. It has been said that a little coal was once shipped from here. But the seam appears very irregular, and, from all that can be seen here now, one would be inclined to pronounce it utterly worthless in every respect.

The outcrop of the Clark Bed can be traced from Stewart's Mine westerly, along the northern brow of the hill just below its crest, as far as the edge of the steep gulch, down the other side of which comes the trail from Somersville over the hill to Stewart's. The outcrop of this bed can also be seen in the top of the hill south of the eastern end of the Pittsburg gangway. But from this last point easterly, across the gulch and the trail, it can be traced on the surface only with difficulty and some uncertainty. But the appearances, so far as they go, would seem to indicate, that, in going easterly from the present end of the Pittsburg gangway, the bed continues to bend somewhat towards the south as it approaches the gulch, and there is every probability that there is in the vicinity of this gulch a great fault, or several faults, resulting in an upthrow of perhaps a couple of hundred feet towards the east. Indeed, it seems certain that the bed here must either be faulted or else very sharply bent. For the course and the position of the eastern part of the Pittsburg gangway are such that, if produced farther towards the east in a straight line, i. e. without any more tendency to the south than it already has, it would pass considerably beneath the plane which the bed is seen to occupy in the western end of the ridge containing Stewart's Mine.

There are undoubtedly other disturbances still to the east of Stewart's; for the course of the beds here is such that if produced in a straight line to the east, it would carry them a considerable distance south of the position which is occupied by the Teutonia Mine.

Considerable work was once done at the Teutonia. A slope was sunk, small but good, hoisting works erected, etc. But the coal is said to have been poor, and the work did not pay. For several years now this mine has been standing idle and the works are going to decay. It is uncertain upon which of the beds it is located.

At the Pacific Mine, on the "Los Meganos,"—better known perhaps as "Marsh's Grant,"—a considerable amount of work has been done and much expense incurred.

At one point a slope and at another a shaft have been sunk. The slope, starting from the croppings, goes down upon a bed of coal with a gentle pitch, which does not exceed 18°, for a distance of about 170 feet. From the foot of this slope a gangway was driven west about 370 feet, and easterly 150 feet or more. At the foot of the slope the bed is three feet thick. But on going from 100 to 200 feet towards the west it widens out to six or seven feet. It contains much "bone," and the coal is soft, shaly, and impure, and contains considerable gypsum disseminated through it in thin sheets and scales. It burns readily, but crumbles easily, and leaves a large percentage of ash. Nevertheless it furnished for a considerable time all the fuel employed for the boilers which drove the somewhat heavy machinery at the shaft.

The shaft, which is situated farther to the north, was sunk to the depth of about 400 feet to reach the same bed as that on which the slope goes down. At the depth of about 30 feet it passed through a seam of coal eighteen inches thick. At the foot of the shaft, on the west side, the bed is seven feet thick, and dips northerly at an angle of 15°. At the top of the bed is about a foot of coal. Below this there is about two and a half to three feet of "bone," containing a streak of clay-slate three or four inches thick, and below this again, from two to two and a half feet of coal. The coal itself, however, at this point is tender, crumbles easily, and is much streaked with "bone."

The east side of the shaft was timbered and planked to the bottom, and we saw nothing here. It was stated, however, that the shaft struck the bed exactly in a fault, and that on the east side there was no appearance of coal, excepting a small streak at a point some fifteen or twenty feet higher than the position which is occupied by the bed on the west, — indicating a considerable upward jump to the east.

At the time of our visit the shaft had only just reached the bed, and the opening to the west did not extend more than thirty or forty feet from the foot of the shaft. After that, however, the gangway was extended west to the distance of about 175 feet from the shaft, and it is said that within the last few feet of this distance the thick stratum of "bone," etc., which occupied the middle of the bed near the shaft, almost entirely ran out, dwindling to only a few inches in thickness, while the quality of the coal itself materially improved. The general character of this bed resembles that of the Black Diamond, as seen at Somersville.

The quantity of water furnished by this shaft was large. The pumps were in two lifts, — those of the lower lift having a 12-inch, and those of the upper one a 15-inch bore, and both lifts having a stroke of six feet. The pumping engine had a 22-inch cylinder and 48-inch stroke, and its gearing was three and a half to one. The hoisting engine had a 14-inch cylinder and 48-inch stroke. All the machinery was good and well put up. The shaft is of good size, in three compartments, and well timbered. Its mouth is somewhere in the vicinity of 130 or 140 feet above the San Joaquin River. All the statements here made respecting this mine refer, unless otherwise specified, to the time of our last visit in May, 1868. For some time now the shaft has been full of water and the mine standing idle.

One or two points worthy of notice were inadvertently omitted above in speaking of the Pittsburg Mine at Somersville. Near the foot of the surface slope in this mine there is to be seen a small streak of coal about eight inches in thickness, which lies about twenty-five feet above the Clark Bed, and is separated from it by shales and sandstone. A similar streak, lying a little above the Clark Bed, has been noticed at a few other points in the mining region, particularly in some of the air-shafts of the Black Diamond Company. But it is by no means persistent, and many of the openings show nothing of it.

The gangway which runs from the foot of the surface slope in this mine, in passing the large fault east of the slope, runs for a considerable distance through the solid sand-rock which underlies the coal. At one point in this locality there is to be seen in the roof of the gangway an isolated and nearly rectangular surface of coal about six inches wide and three or four feet long. Mr. Clarke, the superintendent of this mine, states that in driving the gangway this piece of coal was found to extend obliquely downwards from the roof in the form of a flat cake, with pretty uniform thickness, to about the middle of the gangway, where it ran to a point and disappeared. It is apparently a portion of a detached tabular piece of tolerably pure coal, embedded in and surrounded on all sides by the solid, compact sandstone, and at least twenty-five or thirty feet from any other coal.

Mr. Clarke also states that in a portion of this mine, which is now inaccessible, he has seen sometimes in the clay-slate roof of the coal fine impressions of ferns and other fossil leaves.

In places on the Clark Bed in the Black Diamond Company's mines, the sandstone roof of the bed is covered with irregular and indistinct markings, suggestive of some variety of fossils, rather a poor specimen of which was obtained.

Though almost constantly more or less broken by faults, the main course of strike of the beds through Nortonville and Somersville as far east as the western part of the Pittsburg Mine, a distance of nearly a mile and a half, including the greater part of the important mining operations, is pretty nearly straight, and a little south of east. If, however, we extend our limits, and consider it as a whole from the San Francisco Mine on the west to Stewart's Mine on the east, it will be seen that its general form resembles somewhat that of an archer's bow. Beyond these limits its course is not so certainly known.

With reference to the numerous faults throughout the region of mining operations, though they vary largely in character and in the amount of displacement which they produce, and are sometimes subject to great irregularities, it may yet be stated as a general fact that the directions of their lines of fracture run, obliquely to the course of the beds, N.E. and S.W., and that the direction of the "jump" or displacement which they produce is *generally down to west.*

The average extent of the workings on the Clark Bed through Nortonville and Somersville in the direction of the dip of the bed, including the lengths of the new slopes which have been recently sunk below the lower gangways, is between 1,100 and 1,200 feet, and the bottoms of the mines thus reached vary from 300 to 500 feet above the level of low-water in the San Joaquin River, while from the foot of the Independent Shaft the bed was struck at a point but a few feet higher than the level of the river.

At the greatest depths now accessible the beds show no sign of any tendency to dip less steeply as they go deeper, i. e. to "basin out" as they go towards the valley. Nor, indeed, does it seem likely that they ever will do so in this locality at any depth which will prove accessible to mining operations, when we consider the great thickness of perfectly conformable strata, amounting probably to more than a mile perpendicular to the beds, which overlies them on the north.

Many of the rocks in this vicinity, both above and below the coal, contain considerable lime. Much, even of the silicious sandstone, will effervesce with acids. Gypsum is not uncommon in and about the coal. And here and there, especially a little south of the outcrop of the coal, some tolerably pure limestone may be found. The coal itself contains considerable sulphur in the form of iron pyrites, perhaps also in some organic form.

The mines are beginning to be considerably troubled with water, and pumping is already an expensive item. A drain tunnel might be driven to the Clark Bed, which would be about 7,000 feet in length, and would strike the coal at a little less than 300 feet above low-water in the San Joaquin. This would drain all the mines to this depth. And the sooner the different companies combine to do this work, the more money they will save in their pumping. Indeed, if they could combine more intimately still, and place all the working of the mines under one comprehensive management, they would find it no little economy to do so. For the whole extent of this field at Nortonville and Somersville, including, also, Stewart's Mine on the east, is not by any means too large to be advantageously worked as one extensive colliery.

The water from the mines is a solution of various mineral salts, containing, perhaps, also free sulphuric acid. That from the Independent Shaft especially is about as pleasant to the taste as a strong solution of a mixture of alum, Epsom salts, and copperas, which is pretty nearly what it is.

In the underground work the tracks and cars employed for the transportation of the coal vary considerably.* The strap-rail is here universally used. The gauge of the tracks varies from twenty-seven inches to three feet in the different mines, and the cars hold from 1,500 pounds to a ton of coal.

The sandstone, which covers the Clark Bed at Nortonville and in the western part of the Union Mine, makes a good strong roof, which sometimes remains standing without support until the coal has been worked out under it over large areas before it falls. Little or no timbering is here required in the gangways. The clay-slate roof farther east is not so strong, and requires more care.

On the Black Diamond Bed the "bone" which overlies and underlies the workable coal makes a weak and troublesome roof and floor, not only requiring complete timbering of the gangways, but gradually crushing the timbers and requiring their frequent renewal, and in various other ways materially increasing the expense of working this bed. Moreover, the coal from all these mines, when placed in favorable conditions, shows a disposition to "heat" and a tendency to spontaneous combustion. The "bone" does the same thing. And on the Black Diamond Bed the old workings which have caved and crushed together almost invariably grow hot after a while, if air is permitted to have access to them. This is a source of considerable trouble as well as of some danger to the mine, and renders it never safe to reopen old workings here without the utmost possible precaution.

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* See Notes of 1873.

The coal in these beds generally exhibits two more or less distinctly marked systems of "partings" running through it,—one of them parallel with the stratification of the bed, and the other perpendicular to it and running a little obliquely to the dip.

The analysis of the samples of coal collected will help to show whether there is any variation in its composition dependent upon its depth from the surface. There is no variation in its physical character or its general appearance which can be distinctly traced to this source after a comparatively slight depth is attained below the surface. So far as variations of its physical character are concerned, its practical value, provided it be pure from too much earthy impurity, seems to depend chiefly upon its hardness, i. e. its capacity to bear mining, handling, and transportation, without crumbling too easily and making too much fine "slack." And in these respects the best coal from Stewart's Mine comes now from some distance above the gangway. Moreover, the best coal which can be seen to-day in the Black Diamond Company's mines is in the Upper Black Diamond Mine, some 500 feet above the upper gangway, and within not more than 200 or 300 feet from the surface of the ground. Other instances have not been wanting at different times, when the best coal has come from the upper part of the mines. But, on the other hand, the coal at the bottoms of the new slopes to-day will average as good as the coal from any given level through the mines, while that from the bottom of the Pittsburg Slope is rather uncommonly good and hard.

There has been but little trouble yet with the ventilation of these mines. The natural ventilation is pretty strong, and, where it does not suffice, a little furnace aid is used. Whenever any trouble has arisen in this respect it has been due to carbonic-acid gas, or "black damp," developed in the old workings. In places there is evolved a small quantity of some kind of gas,—probably sulphuretted hydrogen, mixed perhaps with a little sulphurous acid,—which affects the eyes of the miners and makes them sore, besides giving them headaches, if they continue to work long in it.

"Fire-damp," if it ever occurs at all in the Clark Bed, is very rare indeed.* But on the Black Diamond Bed it is not so rare. There has never yet been enough of it here to give any serious trouble or to cause alarm. But there are places in the mine where, if a shoot be driven upwards and left to stand a little while without any outlet above, fire-damp will collect in the top. And several times enough of it has collected in this way to blow a miner out of the shoot somewhat unceremoniously and scorch him pretty severely, when he has carelessly carried his light in the morning up one of these shoots which had been left quietly standing idle over night. Whether enough of it will be found to cause any serious trouble and danger when they go deeper on this bed remains to be seen.

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* See Notes of 1873.

SUPPLEMENTARY REMARKS

ON THE COMPARATIVE VALUE OF DIFFERENT COALS USED ON THE PACIFIC COAST, AND ON THE PROBABLE FUTURE YIELD OF THE MONTE DIABLO COAL-FIELD.

THE Monte Diablo coal is used chiefly for steam purposes. It is burned universally on the river steamers and small steam-craft of all kinds on the inland waters of California. It is also extensively used for stationary steam-engines, and is burned in the locomotives on the Western Pacific and other railroads. It is also used to a certain extent for domestic purposes. It is a tender coal, crumbling easily, and making much "slack" in handling and transportation. It also crumbles very much under the action of the heat when first thrown into the fire, and the whole mass becomes so fine, that, in order to make steam fast enough, it must be burned in a very thin layer, on grate-bars set very close together, and with a good strong draught.

The Coos Bay and the Bellingham Bay coals are used chiefly for domestic purposes, for which they are preferred to the Monte Diablo, although their price is higher.

The chief objections against the Monte Diablo coal for family use seem to be, first, its crumbling so finely in the fire; and second, the supposed greater abundance of its sulphurous and empyreumatic odors. The Bellingham Bay coal is far harder than the Monte Diablo, and bears handling and transportation much better. None of these coals are at all used for the manufacture of gas. They do not cake. And, compared with gas coals, they produce a much less quantity of gas, which possesses a low illuminating power, and is *very* impure, — so much so that it is not only expensive, but also extremely difficult to purify it properly.

The Nanaimo coal is a good clean hard coal. It cakes sufficiently to produce a coherent coke in the gas retorts, is largely used in the manufacture of gas, and is about equal to the Australian coal for this purpose. Besides the Nanaimo and Australian coals, the gas-works also employ Chile coal and English cannel.

The coal from Chile is a caking coal, and produces a little more gas per ton than either the Australian or Nanaimo. But it is an exceedingly tender coal, even more so than the Monte Diablo. On exposure to atmospheric influences it disintegrates rapidly, forming fine "slack," and under favorable circumstances is said to be very liable to spontaneous combustion.

The Australian coal is hard, and bears transportation well.

Mr. Moore of the Risdon Iron Works states that, in a careful comparative trial which he made between the Australian and Monte Diablo coals for steam purposes, he found the former to be worth about 21 per cent more than the latter. Mr. Scott of the Union Foundry states that under good conditions in steam-boilers one pound of Monte Diablo coal will evaporate about five pounds of water. He also states that, in a comparative experiment of two weeks each between the Australian and Monte Diablo coals under the same boilers, he obtained the following results: —

Cost per week with Monte Diablo coal	$16.70
" " " Australian "	13.50
Difference	$3.20

showing a comparative economy of $ 3.20 per week in favor of using Australian coal, the price of which at the time of the experiment was $ 11 per ton, while that of the Monte Diablo was $ 8.60, delivered at the works.

The coal deposits at Monte Diablo are by no means inexhaustible. It is difficult, however, to make any very reliable estimates of the total quantity which this field can furnish, for two reasons.

First, the beds are so much broken, and subject to so many irregularities, that it is impossible to say with certainty beforehand what the condition of the coal will be found to be in any portions which are yet unexplored. And second, it is uncertain to what depth it will prove remunerative to follow such beds in a country like this.

But, if we assume that it will pay to work them to the depth of 1,000 feet vertically below low-water in the San Joaquin River, which, taking into account the slope of the cañons towards the north, would be equivalent to a vertical depth of not far from 1,600 feet below the surface of the ground, and then assume that the Clark Bed will prove uniformly good to this depth for a distance of two miles along its line of strike, and that the Black Diamond Bed will prove good to the same depth for the distance of 4,500 feet along its line of strike; and if we take the quantity so obtained as representing the total capacity of the field, — we shall be making an assumption which is fully as large as the present appearances will justify. If then we assume the average thickness of the Clark Bed to be thirty-three inches, and that of the workable coal in the Black Diamond Bed to be forty-three inches, and make the calculation upon this basis, we shall find for the total amount of workable coal still remaining here, in round numbers, five and a half millions (5,500,000) of tons.*

An approximate calculation of the area already worked out here gives for the quantity of coal which it should have contained about one million two hundred thousand tons.

Of this quantity, the statistics of yield herewith appended account for only 514,144 tons up to January 1, 1870. And if to this last amount we add an allowance of 133,000 tons for the yield during a portion of the time after the mines were first opened, which is not here accounted for, and also for the yield of Stewart's Mine, etc., we shall obtain, in round numbers, 647,000 tons, as the estimated total yield of the Monte Diablo mines up to January 1, 1870. The ground worked should have contained, according to the approximate calculation, 1,200,000 tons. The deficiency of 553,000 tons, or 46 per cent, is to be accounted for by the loss of the greater portion of the pillars, which have been left in the mines, the large amount of waste, and the considerable areas in certain portions of the mines where the coal has been found poor or worthless. The amount of coal which is lost in the pillars will be less in the future than it has been in the past, as the mines are worked with more skill and care. But if we assume that in future the loss from all these causes together will amount to 40 per cent, and make the corresponding deduction from 5,500,000 tons, we shall obtain 3,300,000 tons as an estimate of the total quantity of coal yet remaining, on the 1st of January, 1870, to come from these mines.*

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* See Notes of 1873, for further information on the subject.

As already stated, the annual production is now about 150,000 tons. But this production is increasing, and in attempting to make an estimate of the probable duration of the mines, it will probably not be an overestimate to assume that the average annual production from this time forward will be 200,000 tons. And at this rate of production, according to the above calculation, the mines would last about sixteen and a half years from January 1, 1870.

This estimate must not be understood as intended to be very exact. From the nature of the case this is impossible. It is only given for as good an attempt at approximation as the present developments will allow and justify.

One other point should be noted. This estimate refers only to such a *quality* of coal as is now salable in the San Francisco market. But much of the impure coal or "bone" is of such a quality that it does not seem unlikely that it may be utilized to a considerable extent for certain purposes in the future. And should this be the case it may augment very largely the total product of this field; for the quantity of "bone" in the Black Diamond Bed is very great.

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* See Notes of 1873.

B.

ADDITIONAL NOTES ON THE MONTE DIABLO COAL-MINES.

By W. A. GOODYEAR.

(JUNE, 1873.)

WITHIN the last two or three years one of the smaller seams of coal lying between the Clark Bed and the Black Diamond Bed has been worked to a considerable extent, both in the Union and the Pittsburg mines.[*] This seam has a greater thickness in the Somersville mines than it has farther west in the property of the Black Diamond Company. In the Union and Pittsburg mines it has yielded from fourteen to eighteen inches of good coal. In working a bed so small as this the margin for profit, even under the most favorable circumstances, is of course very small. But, as the roof and floor are both good, and no additional dead-work was required, except an occasional air-shaft or two, it has paid expenses, and a little more.

The Black Diamond Company have purchased within the last two years some additional lands both to the west and north of their original property.[*]

Since 1870 the Lower Black Diamond Gangway has been driven a considerable distance farther east,[†] and a connection made between it and the old "Manhattan Gangway," a few feet above it on the Black Diamond Bed. The latter gangway and the tunnel leading to it from the Clark Bed on the Somersville side of the hill have been reopened and cleaned out, so it is now an easy trip from Nortonville through the hill to Somersville, a distance of about a mile underground.

By this means a large body of good coal has been opened up on the Black Diamond Bed, beneath the high triangular hill, lying within the limits of the old "Manhattan Claim," now belonging to the Black Diamond Company. That is to say, in going east from the Clayton Tunnel on the Black Diamond Bed, after passing a distance of a thousand feet or so within which the bed is utterly worthless, the coal again increases in thickness and quality, and gives in the Manhattan Claim for a distance of 2,000 feet or more an average of about three feet of good solid coal.

That this piece of good coal extends downward also in the direction of the dip of the bed is proved by the fact that the Union Company, whose land lies immediately north of the "Manhattan," and therefore below it on the dip of the bed, have also driven two tunnels to the Black Diamond Bed, one from their

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See Appendix A, page 4.

[†] Ibid., page 6.

gangway at the foot of their surface slope, and the other from the gangway at the foot of their counter-slope on the Clark Bed, the lower one of which strikes the Black Diamond Bed some 700 or 800 feet lower down on the pitch of the bed than the "Manhattan Gangway," and at both these levels in the Union Mine the coal on the Black Diamond Bed is equally good, and three feet or a little more in thickness.

In the "Manhattan Claim" very little coal has yet been taken, however, from this bed. The Black Diamond Company have hitherto found sufficient coal elsewhere to supply the demand, and have therefore held this in reserve.

This portion of the Black Diamond Bed, therefore, though expensive to work, as this bed always is, will nevertheless furnish a large amount of good coal hereafter.

On the 17th of January, 1871, the Upper Black Diamond Gangway* had been driven 4,371 feet westerly from the tunnel, to a point one or two hundred feet beyond the western section-line, and the coal above it pretty much all worked out. Since about that time this gangway has gone no farther, — and it probably never will do so, — because of the facts that the distance to haul the coal underground is very great, and the mining expensive, while at the same time the distance which remains for it to run before it would strike the broken country of the Peacock Mine must be very small. The Black Diamond Bed above the level of the upper gangway being thus practically exhausted of coal already, this gangway is now kept open only for purposes of ventilation and of taking timbers into the mine to supply the breasts between the upper and lower gangways. The expensive automatic plane,† 925 feet in length, built in order to lower the coal from the upper mine to the railroad, is also now of no further use, except for taking up these timbers or props for the mine; and it will probably within a year or two be entirely taken down.

On the 1st of January, 1873, the Lower Black Diamond Gangway† had been driven *west* 3,895 feet from the Clayton Tunnel.

On the 1st of January, 1873, the Clark Bed Main Gangway† had been driven west 5,115 feet from the foot of the "Hoisting Slope," or some 600 or 700 feet beyond the section-line in this direction, and at the same date the gangway from the foot of the "Mt. Hope Slope"† had been driven 4,450 feet west, and its "face" was very near, though it had not yet passed the section-line.

It will be seen that the face of the Clark Bed Main Gangway is the most extreme westerly point to which the present workings in the mines extend. This gangway, though it has curved somewhat to the south in going west, as was expected, has not done so to anything like the degree which the Upper Black Diamond Gangway did.‡ In other words, the two coal-beds here diverge from each other in going west from the Clayton Tunnel, until at the western section-line (i. e. the line between Sections 5 and 6), they are at least twice as far apart (measuring horizontally) as they are at the Clayton Tunnel. But this apparently great divergence is not all of it real, nor indeed most of it. For, in going west, the dip of both the beds diminishes largely, and in places at the extreme west on the Clark Bed Main Gangway the dip is as low as 15° or 16°. This change in the dip alone is of course enough to account for a great difference in the horizontal distance between the beds, the dip at the Clayton Tunnel being about 30°. Yet it seems probable that there is also a little real divergence, and a slightly greater thickness of the strata between the beds.

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* See Appendix A, page 5. † Ibid., page 6. ‡ Ibid., page 9.

But besides these changes in the positions of the beds, actual and relative, in going west, the Clark Bed has already changed its character and become utterly worthless, with no present prospect of improving again in going farther west. Not far from a year ago, a new fault was struck in the Clark Bed Main Gangway, in the shape of a considerable jump down to the west, at a point some 600 or 800 feet back from the present face of the gangway. The coal up to this fault was good. But immediately beyond, i. e. to the west of it, the coal stratum began to diminish in thickness, and a new thing, not previously seen anywhere in the Clark Bed, made its appearance, in the shape of a little clay streak of barely perceptible thickness in the centre of the bed. In going farther west, this clay streak has thus far not only proved persistent, but has gradually and steadily increased in thickness, while the two layers of coal above and below it have as steadily diminished, until now, at the present face of this gangway, all that is left of the Clark Bed is two little streaks of coal, each three or four inches only in thickness, and separated by three or four feet of intervening clay rock. The gangway has been steadily pushed ahead, in the hope that the coal streaks might again unite and increase in thickness enough to make a workable bed. But the only result so far has been a change from bad to worse, both in appearances and prospects.

The Mt. Hope Gangway is also now rapidly approaching the same fault, and has but a short distance yet to run before it reaches it.

Nearly all the coal of any value above the Clark Bed Main Gangway has already been extracted. And the coal between this gangway and the Mt. Hope Gangway is also worked out well up towards the face of the latter gangway.

The Clark Bed therefore is already very nearly, and within a few months will be completely, exhausted above the level of the Mt. Hope Gangway.

Within the last three years the Eureka Company * have worked out all the coal that remained on the Clark Bed within the limits of their ground; and recently both the Eureka and the Independent Claims have been purchased by the Pittsburg Company.

They are now using to a considerable extent a light T rail for the underground tracks in the Monte Diablo mines.†

Recently, in the western part of the Black Diamond Company's mines, towards the face of the Clark Bed Main Gangway, they have occasionally had considerable quantities of fire-damp.‡ But, as the ventilation is good, it has caused no serious trouble.

A safety-lamp, however, is always kept on hand, and whenever and wherever there is cause to suspect the possibility of any accumulation of the gas, no naked light is allowed to go.

The Coos Bay coal certainly does contain a large amount of sulphur, impressions or opinions to the contrary notwithstanding. So far as I could judge from all

* See Appendix A, page 17. † Ibid., page 23. ‡ Ibid., page 24.

appearances of the coal in and about the mines, and in the burning waste-heaps at Coos Bay in the fall of 1872, I should think the quantity of sulphur would average as great in the Coos Bay coal as in the Monte Diablo.

Any popular opinion which exists at present respecting the quantities of sulphur which these different coals contain, or even respecting their relative values for domestic purposes, is worth but little. This is due partly to the fact that so many people do not know the difference between the odor of sulphurous acid and the odors of the empyreumatic substances which the coal contains, and partly to the fact that very often people do not know what coal it really is that they are burning. It is notorious that some of the dealers here are in the habit of selling at the various market prices two or three of these different kinds of coal, — all from the same heap. And in such cases the heap is generally from Monte Diablo, as that is now the cheapest coal in this market.

With reference to the estimate made* of the quantity of coal yet remaining to be extracted from the Monte Diablo coal-field, it should be specially noted that that estimate was based upon the assumption that it would pay to follow and work these beds to a vertical depth of 1,000 feet below the level of low-water in the San Joaquin River. But I consider it now, to say the least, extremely doubtful whether it will ever pay to work these beds so low as this.

One thing in particular, which, in a country like this, is destined to modify very materially the extent to which it will pay to work the Monte Diablo mines, is the Seattle coal-field in Washington Territory.

It is probable that within less than five years from this date (June, 1873) the coal from the Seattle mines will be laid down on the wharves in San Francisco at a less actual cost price per ton than the Monte Diablo coal can be furnished for. Indeed I believe that, with the requisite capital and good management, this might be accomplished within less than two years from now.

Furthermore, the cost of production per ton at Monte Diablo is steadily increasing, and will continue to do so more and more in the future; while at Seattle, if well managed, it would remain nearly constant for a lifetime. Again, the Monte Diablo coal-field, at best, will last but a very limited term of years, while the Seattle field is practically inexhaustible for generations.

Moreover, the quality of the Seattle coal is considerably better than the Monte Diablo. It is a harder and better steam coal, contains less sulphur, and is far less liable to spontaneous combustion, when piled in mass.

Under such circumstances it is not difficult to foresee the result, whenever Seattle coal shall come fairly into competition with Monte Diablo.

Within the past year the Seattle Coal Company, working under every disadvantage, from lack of means, bad management, high prices paid to miners and for transportation, etc., have laid down and sold in this city over twenty-five thousand tons of coal at an average price of over ten dollars per ton. The average price commanded in this market, for three consecutive months of last winter and spring, by Seattle screenings for steam purposes, was $ 8 per ton, while Monte Diablo screenings sold for $ 6.50.

* See Appendix A, page 26.

The Seattle Company, so far, have not made money, but have just about paid expenses.

They have done enough, however, to demonstrate that, with adequate capital and proper management, the cost price of their coal delivered in this city can be reduced to not over 50 per cent of what it has hitherto been.

The Monte Diablo mines in the aggregate have been paying for several years a profit equal to one per cent monthly dividends on something like four millions of dollars.

The nominal capital of the Black Diamond Company itself is five millions.

I should consider the Seattle coal-field, undeveloped as it lies to-day, a better and safer investment at five millions of dollars, or indeed at any other price, than the whole of the Monte Diablo mines for an equal sum.

Coos Bay, also, is utterly insignificant in comparison with it.

C.

STATISTICS OF THE MONTE DIABLO COAL-MINES.

By W. A. GOODYEAR.

(JANUARY, 1874.)

The annexed table exhibits in collective form the statistics of actual production by the Monte Diablo Coal Companies, so far as I have been able to obtain them up to the 1st of January, 1874.

The complete statistics of the Black Diamond Company were furnished from the books of that company by the courtesy of its President and Agent, Mr. P. B. Cornwall.

The product of the Union Mine for 1865 and 1866 was furnished from the books of the Union Company.

The product of the Union Mine from 1867 to 1870 inclusive, and the product of all the other Somersville mines from 1866 to 1870 inclusive, were furnished from the books of the Pittsburg Railroad Company, over whose railroad all the coal from those mines was transported to Pittsburg Landing.

The yield of the Central (i. e. Stewart's) Mine, for the three years from 1868 to 1870 inclusive, is included in the figures given for the Black Diamond Company.

No coal has been shipped by the Manhattan Company since 1866, and none has been shipped by the Independent, separate from the Eureka, since 1867.

For 1866 and 1867, therefore, these returns are complete, with the exception of the yield from the "Central," and possibly also a small quantity from the "San Francisco" and "Teutonia."

From 1868 to 1870 inclusive they are complete, with the exception of a very small quantity from the "San Francisco."

Previous to 1866 I have been able to find no exact accounts of the Somersville mines, except the single item of the product of the Union Mine in 1865.

The only thing prior to that date is newspaper statistics.

According to a table, however, which was published in the San Francisco "Daily Alta" for April 4, 1870, and which appears to have been carefully compiled, the total production of the Monte Diablo mines, from 1861 to 1869 inclusive, was 647,283 tons. This is probably very near the truth. At all events, it is as near as anything which is now obtainable. Assuming it then to be correct, if we add to it the production for 1870, namely, 129,723 tons, we may say, in round numbers, that the total product of the Monte Diablo mines for the first ten years of their existence was 777,000 tons; and of this it is probable that nearly 750,000 tons came from the mines of Somersville and Nortonville alone.

The complete statistics for the last three years, from 1871 to 1873 inclusive, were furnished by the kindness of Mr. Cornwall.

The cost of extracting the Monte Diablo coal varies very largely at the different mines, and under different circumstances in the same mine.

The cost of transportation and delivery is also very different for the different companies.

Indeed, the variation in these respects is so great that the exact figures for one mine would be no index whatever to those of another, while the figures for the same mine in different years would vary very largely.

I am not at liberty to give exact statements on these points from any of the mines.

But the general statement may be made, that the total average cost of mining, transportation, and delivery of all the Monte Diablo coal extracted in the year 1870 was between $5 and $5.50 per ton; and that it was less in that year than in any preceding one. This is exclusive of all interest on the capital invested, which is large, and which interest must be added to the above statement in order to get the actual cost of the coal.

The cost at present, however, is somewhat greater than it was in 1870, as the cost of mining has since then been steadily increasing.

STATISTICAL TABLE OF THE YIELD OF THE MONTE DIABLO COAL-MINES, 1861 - 1873.

Year.	Black Diamond Co.	Pittsburg Co.	Union Co.	Eureka Co.	"Stewart's Mine" or Central Co.	Independent Co.	Manhattan Co.	Totals.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
1861	1,370	... ...	... ...	... ...	... ...	... ...	... ...	1,370
1862	10,672	... ...	... ...	... ...	... ...	... ...	... ...	10,672
1863	14,232	... ...	... ...	... ...	... ...	... ...	... ...	14,232
1864	12,421	... ...	... ...	... ...	... ...	... ...	... ...	12,421
1865	14,491	... ...	11,187	... ...	... ...	... ...	... ...	25,678
1866	16,009	9,599	14,224	7,391	... ...	15,678	65	62,966
1867	38,368	21,909	24,167	10,908	... ...	14,338	... ...	109,690
1868	70,100	22,920	21,641	15,815	... ...	... ...	... ...	130,476
1869	84,482	27,938	17,274	16,945	... ...	... ...	... ...	146,639
1870	74,956	23,958	20,563	10,246	... ...	... ...	... ...	129,723
Totals, first ten years	337,101	106,324	109,056	61,305	... ...	30,016	65	643,867
Estimated additional quantity produced in first ten years and unaccounted for above . . .								133,133
Grand total for first ten years								777,000
1871	75,236	22,339	17,209	18,194	*7,215	... ...	... ...	140,193
1872	102,388	26,714	21,494	16,831	*9,612	... ...	... ...	177,039
1873	104,106	32,362	22,600	4,075	8,578	... ...	... ...	171,721
Totals, thirteen years	618,831	187,739	170,359	100,405	25,405	30,016	65	1,265,953
Add for the last three years an average quantity of 1,000 tons per month consumed in pumping and hoisting at the mines								36,000
Grand total of production for thirteen years, up to January 1, 1874								1,301,953

* These figures are only approximate, but cannot be far from the truth.

D.

NOTES DESCRIPTIVE OF THE CONDITION OF THE CORRAL HOLLOW COAL-MINES.

By W. A. GOODYEAR.

(AUGUST, 1870.)

The following notes of a visit which I made in August, 1870, to the Corral Hollow Coal-Mines and their vicinity are compiled partly from my own observations and partly from statements made to me by others.*

Everything in these notes relating to that which is now exposed and may be seen upon the surface of the ground is from my own observations, unless otherwise specially mentioned; so also are some notes relating to underground appearances at the "Eureka," formerly known as the "Pacific" Mine. But this was the only mine at Corral Hollow which at the time of my visit was in such a condition that it could be entered.

All notes, therefore, with reference to the character and extent of the underground works at the other mines, or the character of the developments made by them, are from the statements of others. For the accuracy of these statements, therefore, I cannot vouch; although, with these explanatory remarks, I shall give them in full.

From Ellis Station on the Western Pacific Railroad it is about four miles by the road to the mouth of Corral Hollow Cañon, and from thence about ten miles farther up the cañon to the locality of the Eureka, or Pacific Mine. The other mines are situated from two and a half to three miles farther down the cañon. A branch railroad track was laid from Ellis to the mouth of the cañon, but no farther.

From the eastern edge of the mountains proper Corral Hollow Cañon continues on for nearly a mile, I should think straight easterly, — being here perhaps from a third to half a mile wide, and bounded on each side by banks, which, near the mountains, are several hundred feet high, but which fall with a smooth and gentle slope towards the east, and finally disappear in the level plain. From within the cañon these banks are seen to be, in places, more or less terraced, and they have evidently been formed by the creek, which has gradually cut its wide deep valley from the broad and gentle slope, which extends from the foot of the mountains eastward towards the more level plain.

In an exposed bank in the cañon near its bed on the left bank of the creek at the edge of the mountains, I noticed the unaltered sandstones striking northerly, and dipping gently — perhaps 10° to 15° — to the east, and immediately overlaid unconformably by ten to twelve feet of still more recent horizontal beds.

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* See Geology of California, Vol. I. p. 35.

At a point a short distance above the mouth of the cañon the dip of the strata on the south is southerly, and of those on the north of the cañon is northerly, while a little west of here, in the bed of the cañon itself, the strike is northerly and the dip is westerly, the whole thing looking very much as if the strike at this locality made a sort of horseshoe bend, the rocks themselves being curved in a great conoidal flexure.

For some three or four miles from its mouth the cañon is crooked, irregular, and narrow, and shut in by very steep and often bluffy hills. Beyond that, the cañon widens out into a little valley, perhaps a quarter of a mile in width, and runs with slight curves, but with a very straight general course, nearly due magnetic west up to the big bend of the creek near the Eureka Mine at the edge of the metamorphic country.

A portion of the afternoon of August 24 was spent in hunting for the locality of fossil leaves, noticed on page 38 of Geology of California, Vol. I.

On inquiry it appeared that "Adams's Spring" — the locality of "Camp 61" — was the one now known as "Hunter's Spring," and located on the north side of the cañon some three miles below the Eureka Mine, and about half a mile below Hennessey's house. I searched through the hills north of there, but failed to find the locality in question.

I found, however, the surface of some of the hills here covered with pebbles, which appear to be *volcanic* in origin, and which proceed from adjacent beds of conglomerate. These pebbles are all rounded by water, and they are very plenty here on some of the hill-tops, though most of the pebbles in the bed of Corral Hollow Cañon itself are metamorphic.

The rocks in this vicinity are poorly exposed, but, so far as seen, they seemed to dip southeast. In the little cañon just north of Hennessey's house I found the rocks standing nearly vertical, with a strike of from N. 80° E. to S. 70° E. magnetic.

On the morning of the 25th of August I visited the Eureka, or Pacific Mine. There seems to have been but very little work done here since the time of Professor Brewer's visit, nothing having been done, as I was told, since 1862, except that lately the tunnels and gangway have been cleared of rubbish and partially re-timbered. The gangway was said to be about 600 feet long, — its direction being about N. 80° W. magnetic. Two tunnels lead into this gangway, — one about 300 feet long in a direction N. 40° W. magnetic; the other one somewhat shorter, and running about N. 25° E. magnetic, i. e. much more nearly at right angles to the gangway than the first. The mouths of these tunnels are but a few feet apart. The level of these drifts is said to be about eighty feet above the bed of Corral Hollow Creek. A short distance west of the point where the "main tunnel" (whose course is N. 40° W.) strikes the bed, an air-shaft has been driven up about seventy-five feet to the surface.

I could nowhere see the full thickness of the bed, as the timbering hides it. But at the bottom of the shaft just mentioned, I saw some very pure-looking coal, of which I took specimens.

The fault which is mentioned near the bottom of page 37, Geology, Vol. I., was stated to be at the west end of the gangway, which has been driven no farther in this direction.

But I think the chances are that there is no very great displacement at this point, inasmuch as the same heavy bed again appears nearly on its proper course in the next cañon, some 200 or 300 yards farther west.

In this cañon also a tunnel has been opened, and driven westerly on the bed. This tunnel is said to have been about 600 feet long, and it is at a considerably higher level than the works above described. Near the mouth of this tunnel another carbonaceous streak may be seen, some twenty-five or thirty feet south of the main bed, and underlying it. It was stated to me that at the farther end of the tunnel a drift had been opened southerly across the strata, which were there forty-five feet thick, to this second bed, which at that point exhibited a thickness of "five feet of good (?) coal."

Still farther south, and somewhat lower down the cañon, there is a third bed of carbonaceous matter, several feet in thickness, on which a tunnel has been driven in westerly about 100 feet, and a shaft then sunk, as was stated, to a depth of 60 feet below. This opening exhibits coal, though it is friable and impure.

The croppings everywhere near the surface here are soft and friable, as indeed they generally are at the Monte Diablo mines also.

On leaving the Eureka Mine, I travelled with Mr. Carroll about a mile down Corral Hollow Cañon, and then climbed nearly to the summit of the first high hills to the north of the cañon. Here at the head of a little gulch, about a quarter of a mile east of a deep side-cañon, we found another locality of fossil leaves, of which I collected specimens. This locality is very nearly midway between the Eureka Mine and the old shaft on the "Commercial" Company's ground to the west of their present shaft. The old shaft here referred to is very probably the same one which is mentioned in Vol. I. of the Geology, pp. 37 and 38, as having been sunk by the "Coast Range Company." The dip at this locality is to the north.

Between the Eureka and the old shaft of the Commercial Mine the coal bed or beds appear to gradually cross the cañon, being on the south side of it at the latter locality.

At a point about three quarters of a mile below the Eureka Mine the apparent outcrop of the large bed was seen in a little bluff near the bed of the creek, and the strike here is nearly the same as at the Eureka, while the latter mine itself bears N. 85° W. magnetic. But the dip at this point is nearly vertical.

The old shaft of the Commercial Company is, according to Mr. Carroll, 200 feet deep, with a drift 180 feet long running southerly from its bottom. The shaft is not on the coal, and he says the drift did not reach the coal.

The new shaft in the large building had only been sunk about 80 feet. It was not on the coal, and no drifting had been done from it.

The third and lowest shaft of the Commercial Company is on the coal, and is said to be about 300 feet deep, and to have furnished all the coal which came from the Corral Hollow mines in 1869 and 1870. But at the time of my visit the little building which covered the mouth of the shaft had been burned down, the mine itself was on fire, and it was not safe to go anywhere near the mouth of the shaft.

I was informed that on the boundary-line between the ground of the "Commercial" and that of the "Eureka" Company there was, in 1857 or 1858, a shaft sunk 100 feet, and the strata and the coal found to be vertical, the latter being forty inches thick. At the lower "Commercial" shaft the dip is southerly, though steep.

At the "Almaden" Mine, next east of the Commercial, the shaft is said to have been 300 feet deep, and a tunnel driven southerly from its foot to have been 700 feet long. It is now caved full to within thirty or forty feet of the top.

In the mouth of the little cañon just south of the Almaden Mine the strike is N. 75° to 80° W., and the dip about 45° southerly. One or two hundred feet farther up the cañon, where a little tunnel has been driven in forty or fifty feet easterly on a seam of impure coal, varying from an inch or two to a foot in thickness, the strike is nearly the same, but the dip is vertical.

From the Eureka Mine to Hennessey's house, in descending the Corral Hollow Cañon, the strata in the hills to the north present nearly all the way the appearance of having a northerly dip, though the exposures are so poor that it is not possible to decide with certainty from a distance.

Following up the cañon to the north just back of Hennessey's house, the rocks at first near its mouth are seen at one or two points, as already stated, to strike nearly the same as on the south, or opposite, side of the main cañon, and to stand nearly vertical.

But above here there are no more exposures until we reach a point about a mile N. 20° W. magnetic from the house.

At this point we reach the southwest edge of a heavy mass of strata, forming all the highest points just north of here, and which are well exposed and everywhere in this vicinity strike northeasterly, — generally N. 40° to 60° E. magnetic, and dip southeasterly at gentle angles, — from 10° to 20°. The course of the southwest edge of this mass of strata is here about N. 65° to 70° W. They are unaltered sandstones and shales, together with beds of the conglomerate containing volcanic pebbles already noticed.

At a point in this vicinity just east of the gulch I found some thin clay seams immediately underlying a bed of this conglomerate, some six or eight feet thick, and containing a few fossil leaves, and occasional bits of fossil wood, of which I took specimens. It seems likely that these leaf-bearing beds are spread over a considerable area here, and that they may be found at numerous points.

The following notes, together with the successive distances in decimals of a mile, as estimated by timing my rate of travel from the Eureka, or Pacific Mine, down Corral Hollow Cañon to its mouth, and thence to Ellis Station, will assist materially, I think, in rendering the situation of things intelligible here: —

Miles.
0.00 — O'Brien's house near Eureka Mine.
0.75 — Outcrop of coal-bed in cañon. — Vertical.
0.15 — Deep side-cañon comes in from north.

0.35 — Opposite locality of fossil leaves in hills to the north.
0.60 — A house on north side of cañon.
0.05 — Upper and old shaft. — Commercial Company.
0.20 — New shaft, 80 feet deep. — Commercial Company.
0.05 — Lower shaft, 300 feet deep. — On fire! — Commercial Company.
0.30 — Another old shaft on south side of cañon.
0.20 — Hennessey's house. — Opposite Almaden Mine.
0.60 — "Hunter's Spring," called also "Adams's Spring." The strike of the rocks in the lower hills near the north edge of the cañon here is northeasterly, and the dip southeast, very gentle, — perhaps 8° or 10°.
0.45 — A little shaft and windlass on the north side of the cañon, with a small, but very black dump-pile of coaly matter, and a little cabin near by.
0.80 — A slight bend in the cañon, the course for some distance now being about N. 65° E. magnetic.
0.75 — The rocks both north and south of the cañon dip southeast.
0.20 — A stake on the county line between the counties of Alameda and San Joaquin.
0.90 — A house on the right of the road. The main cañon here makes a sharp bend to the north, the course becoming about N. 5° E. magnetic.
0.10 — "Castle Rock," — a heavy mass of conglomerate on the right of the cañon, cropping out in a rough bluff, and striking N. 65° E., and dipping gently (perhaps 5° to 10°) to the southeast.
1.80 — Another sharp bend of the cañon to the east, below which, though quite narrow and crooked in detail, its *general* course is pretty straight, and nearly *east* magnetic. The rocks just west of this bend strike about N. 20° E., and dip not far from 20° to the west. And in general, between this bend and the last one before mentioned, the strike of the rocks on the west of the cañon appears to be northeasterly or northerly, and the dip westerly.
1.00 — A little prospecting tunnel or slope on the south side of the cañon, going down with the dip of the strata, where the rocks strike about N. 50° E. magnetic, and dip 10° southeast. This thing had been driven 40 or 45 feet at the time of my visit (August 26), and was still progressing. The rocks here are sandstones and dark-colored clay shales, with here and there a few little reticulations of coaly matter, from an eighth to a quarter of an inch thick. There was, however, no earthly indication here of the existence of a ton of coal anywhere in the vicinity. On the opposite (i. e. the north) side of the cañon here, and perhaps a quarter of a mile off, the rocks seem also to strike northeast, but dip northwest.
0.60 — End of railroad track at mouth of cañon.
4.00 — Ellis Station.

It will be seen that the total distance by this estimate from Ellis Station to the Eureka, or Pacific Mine is 13.85 miles.

From Ellis Station the apparent gap in the foot-hills at the mouth of the Corral Hollow Cañon bears about *south* magnetic, and this gap, as seen from here, has the smooth round top of a lower hill in front of it, forming an apparent knob right in its centre.

With reference to the Commercial Mine, I was also informed that the second level in the mine was at the depth of 150 feet from the surface, and that it was driven from the shaft which is now on fire about 150 feet to the east and some 325 feet to the west, and that all the coal hitherto furnished by this mine has come from above this level. The lower levels were said to have been driven only some thirty or forty feet from the shaft.

If it should ever be desirable to complete the branch railroad from the mouth of the cañon up to the mines, it will be found that from its present terminus at the mouth of the cañon to the bend at "Castle Rock," a distance of nearly 3½ miles, the expense of construction will be heavy, and some pretty sharp curving will be necessary. The grades required within this distance will also be high, though not by any means so great, I think, as the maximum grades of the present railroads at the Monte Diablo mines. Indeed, as nearly as I could judge by the eye, I should think that no grade exceeding 150 feet to the mile would be needed.

For the remainder of the distance from the "Castle Rock" to the mines the road can be very cheaply built, with an easy grade.

I do not know why the prospects of the Eureka, or Pacific Mine should not be fair, *provided* the cost of transportation and the circumstances of the market, etc., should ever permit (which they will not do at present) the mines at this locality to compete upon anything like favorable terms with those at Monte Diablo.

The examination which I could make was of course imperfect. But I saw no evidence that the disturbances of the strata for a distance of some 2,000 feet to the east from the Eureka Mine are any greater than in the Monte Diablo region.

With reference to the character of the coal from this mine, so far as cleanness and purity go, it appeared very fair. And some of the specimens which I obtained appeared quite hard when taken from the mine, though on examining them two or three days later I found them already badly cracked and crumbling.

But it should be remembered that these specimens came from only seventy-five or eighty feet beneath the outcrop, and that at the Monte Diablo mines the coal near the surface is generally poor; while in the gangway whence these specimens were taken the coal has also in reality been for years exposed to the action of the atmosphere as well as that of the water in the mine.

E.

CHEMICAL EXAMINATION OF PACIFIC COAST COALS.

By S. F. PECKHAM.

I.

(JULY, 1872.)

The samples of coal sent me for examination were numbered 51, 52, 53, 54, 55, 56, 57, 57, 57, 59, 60, 61, 62, 62*a*, 63, 64, 65, 66, 67, and 68. There were three specimens numbered 57, one of which was marked in red paint "Eel River." This specimen is numbered, in this report, 57*b*; the others are numbered 57*a* and 57*c*.

The specimens were all submitted to a process of proximate analysis under conditions as nearly identical as possible. This process had for its object the determination of, *firstly*, the percentage of matter volatile under a temperature of 250° Fahr.; *secondly*, the percentage volatile at a white heat; *thirdly*, the amount of combustible matter remaining; and, *fourthly*, the amount of ash.*

The coal was first pulverized so finely that all of the pieces would pass through a sieve of thirty holes to the linear inch. The coarsest particles were separated by a finer sieve, and any dust adhering to them was removed by a sieve of fine muslin. These pieces of nearly uniform size were used for the determination of the specific gravity, and were placed in a separate bottle.

The powdered coal from which the coarser particles had been removed was placed in a closely corked bottle and used for the proximate analysis.

One gramme was carefully weighed out in a half-ounce platinum crucible, and dried in an air-bath constructed as follows. A shallow four-inch iron sand-bath was filled to one half inch in depth, and placed upon a tripod. Upon the sand was laid a copper plate about two inches square. A cone, like an ordinary tin funnel without a neck, and provided with a handle, was inverted over the sand-bath. At the apex of the cone was a half-inch orifice stopped with a cork, through which passed a thermometer tube. The thermometer bulb touched the copper plate on which was placed the uncovered crucible. This bath could be heated with but slight variation for twenty-four hours.

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* This process is essentially that used by me for the analysis of the Iowa coals. (See "Geological Survey of Iowa," Vol. I.) I was the first, I believe, to call attention to the importance of a careful determination of the water contained in our coals, as an element of the greatest importance in judging of their economical value. — (J. D. W.)

Each specimen of pulverized coal was heated fifteen minutes, and then weighed. It was heated again and weighed at intervals of ten minutes until the weight either remained constant or increased. The loss in weight was estimated as ***hygroscopic moisture.*** A variation in the temperature of ten degrees produced no difference in the result, so far as was ascertained.

The crucible was then covered and heated three and one half minutes in the flame of a Bunsen's lamp; then without removing it from the flame it was heated the same length of time in the flame of a blast lamp. The loss in weight was estimated as *volatile combustible material.*

The crucible was then uncovered and inclined, and the contents burned to an ash in the flame of a Bunsen's lamp. Whenever coke was formed the combustion was made in oxygen. After weighing, the loss was estimated as *fixed carbon.*

The residue was estimated as *ash.*

I have not been able to devote any time to an examination of this process. It is accepted among chemists as the best yet devised. The weighings were made on a balance sensitive to one tenth of a milligramme, or to one ten-thousandth of the amount taken. The loss was thus directly expressed in terms of hundredths of one per cent. Whatever may be the intrinsic value of the process, it furnishes a valuable means for the technical comparison of coals, and admits of repetition with a great degree of accuracy; especially with reference to the first and last items, and consequently with reference to the sum of the second and third items. This sum represents the total combustible material contained in the coal. The percentage of combustible material volatile under the conditions named was found to vary somewhat even when those conditions were made as nearly identical as possible. I have been unable to ascertain the cause of this variation. As an example I will cite No. 59 (Black Diamond Company's Mine). Two analyses gave, —

	Moisture.	Volatile.	Fixed.	Ash.
	15.05	41.26	30.94	12.75
	14.98	41.61	30.67	12.74
Difference,	.07	.35	.27	.01

The difference between the two first and two last items is less than one tenth of one per cent; while the difference between the two second and two third items is more than one quarter of one per cent. If, however, the second and third items in each analysis be added together, the sums will be very nearly equal; thus, —

Volatile,	41.26	41.61
Fixed,	30.94	30.67
	72.20	72.28

The variation for this total amount of combustible material is eight hundedths of one per cent. In nearly all the results here given, the difference between the two analyses, of which the result given is the mean, was less than one tenth of one per cent in the three items of moisture, total combustible material and ash.

The specimens were kept under the same conditions as regards atmospheric moisture, and were analyzed as they were taken from the box without regard to the numbers.

No. 67 (from Los Bronces, Mexico) is an anthracite, containing 85.385 per cent of fixed carbon.

Nos. 52 (Nanaimo), 53 (Chili), 55 (Comox), 62 (Q. Charlotte Isl.), 64 (Sydney), 65 (Nanaimo), and 66 (Saghalien) are caking coals, leaving as a residue, when heated to a white heat, a mass of coherent coke of more or less difficult combustibility.

The remaining numbers, 51 (Bellingham Bay), 54 (Coos Bay), 56 (Corral Hollow), 57 *a*, *b*, and *c* (Eel River), 59, 60, 61, 62 *a*, 63 (Monte Diablo coals), 67 (Los Bronces), and 68 (Seattle), are non-caking coals, leaving when heated to a white heat a mass having about the volume and appearance of the original coal. In some cases there was a slight coherence of the particles upon the surface, but they fell apart as soon as they were touched.

The time required to expel the matter volatile under 250° Fahr. varied from fifteen to forty minutes; but a very large proportion of it was in all cases expelled in fifteen minutes.

Nos. 52 (Nanaimo), 53 (Chili), 55 (Comox), 62 (Q. Charlotte Isl.), 64 (Sydney), 65 (Nanaimo), and 66 (Saghalien) contained less than four per cent of matter volatile under 250° Fahr., and these numbers embrace all of the caking coals.

Nos. 51 (Bellingham Bay), 54 (Coos Bay), 57 *a*, *b*, *c* (Eel River), and 67 (Los Bronces) contain less than ten per cent of matter volatile under 250° (water).

Nos. 56 (Corral Hollow), 59 (Black Diamond), 60 (Union Mine), 61 (Stewart's Mine), 62 *a* (Clark Bed), 63 (Black Diamond), and 68 (Seattle) contain from 11.56 to 15.005 per cent of matter volatile under 250° Fahr.

For various reasons, which I have not yet been able to verify, I do not believe that in the majority of specimens examined this matter volatile under 250° is *all* hygroscopic moisture, but that absorbed gases form a large proportion of it.*

Excluding Nos. 62 (Q. Charlotte Isl.) and 67 (Los Bronces), the amount of matter volatile under a white heat amounted to from 31.165 to 48.51 per cent, averaging about 41.5 per cent.

With the exception of No. 67 (Los Bronces), the fixed carbon amounted to from 30.805 to 56.14 per cent, averaging about 41.5 per cent.

No. 67 (Los Bronces) has 3.23 per cent of ash; Nos. 57 *c* (Eel River), 63 (Clark Bed), and 65 (Nanaimo) have between five and six per cent; Nos. 57 *b* (Eel River), 60 (Union Mine), 61 (Stewart's Mine), and 68 (Seattle) have between six and seven per cent; Nos. 54 (Coos Bay) and 57 *a* (Eel River) have between seven and eight per cent; Nos. 53 (Chili), 62 *a* (Clark Bed), and 66 (Saghalien) have between eight and nine per cent; No. 55 (Comox), between nine and ten; Nos. 51, 52, 56, 59, and 64, between ten and fourteen; and No. 62 has 31.735 per cent of ash.

The ashes vary in color.

Nos. 51 (Bellingham Bay), 53 (Chili), and 54 (Coos Bay) are yellow.
" 52 (Nanaimo), 55 (Comox), 64 (Sydney), 65 (Nanaimo), and 67 (Los Bronces) are brown.
" 62 (Q. Charlotte Isl.) and 68 (Seattle) are greenish-brown.
" 59 (Black Diamond) and 63 (Black Diamond) are very white, as white as bone ash.

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* See farther on, p. 46, where this opinion is proved to be incorrect. — (J. D. W.)

Nos. 56 (Corral Hollow), 57 *a*, *b*, *c* (Eel River), 60 (Union Mine), 61 (Stewart's Mine), and 62 *a* (Clark Bed) are purplish-white.

The ash of No. 66 (Saghalien) fused to a globule when the coke was burned in oxygen gas.

I have not discovered that the amount or appearance of the ash bears any relation to any other characteristics of the coal.

Arranged according to the total amount of combustible material that they contain, their relative value would appear as follows: —

1.	No. 65 (Nanaimo),	90.735	per cent.
2.	" 66 (Saghalien),	89.41	" "
3.	" 67 (Los Bronces),	89.39	" "
4.	" 55 (Comox),	88.87	" "
5.	" 53 (Chili),	87.80	" "
6.	" 64 (Sydney),	86.725	" "
7.	" 57 *c* (Eel River),	86.39	" "
8.	" 52 (Nanaimo),	85.18	" "
9.	" 57 *b* (Eel River),	84.80	" "
10.	" 57 *a* (Eel River),	84.21	" "
11.	No. 54 (Coos Bay),	83.215	per cent.
12.	" 60 (Union Mine),	81.795	" "
13.	" 63 (Black Diamond),	81.785	" "
14.	" 61 (Stewart's Mine),	80.505	" "
15.	" 62 *a* (Clark Bed),	80.225	" "
16.	" 68 (Seattle),	80.115	" "
17.	" 51 (Bellingham Bay),	78.505	" "
18.	" 59 (Black Diamond),	76.385	" "
19.	" 56 (Corral Hollow),	72.240	" "
20.	" 62 (Q. Charlotte Isl.),	67.085	" "

Nos. 1 and 2 are caking coals. No. 3 is an anthracite. Nos. 4 and 5 are caking coals. No. 7, a non-caking coal, thus appears to be more valuable, and Nos. 9 and 10 but little less valuable than No. 8; but this inference may not be a fair one, as we do not know of what the 8 to 8.5 per cent consists, which is volatile under 250° Fahr. If, as has been supposed,* it consists of vapor of water, it is injurious excepting under conditions not likely to occur in furnaces of ordinary construction, as it requires a large amount of heat for its evaporation. If it be nitrogen or carbonic acid, they would convey a great deal of heat up the flue. If it be oxygen, — a supposition hardly probable, — it would only increase the rapidity and intensity of the combustion. In Nos. 7, 9, and 10 the percentage of this volatile matter is two and one half times greater than in No. 8, while the percentage of ash in No. 8 is nearly twice that found in the others; yet No. 8 may be much more valuable than either of the three.

The total amount of combustible material here given includes the sulphur and phosphorus, and the ash includes the loss in weight of the platinum crucible, which amounted in some instances to a few tenths of a milligramme, corresponding to as many hundredths of one per cent.

The table on page 48 gives the results of the analyses of all the specimens.

II.

(SEPTEMBER, 1872.)

In a letter addressed to the State Geologist of California, dated July 2, 1872, accompanying a partial report upon the coals submitted to me for examination, I stated that I wished "to finish the determination of the specific gravities; — to determine the sulphur quantitatively; to determine the phosphorus qualitatively, unless it appears in considerable quantity; to analyze the ashes qualitatively; to determine the nature of the matter volatile under 250° Fahr., in four or five of the specimens that contain it in largest quantity; and to examine the absorbent action of the coals and residues." While estimating the sulphur I was surprised to find so large an amount as five per cent in some specimens, and afterwards, while examining the ashes, I found that all of them, and especially those of the non-caking coals, contained lime in notable quantity. It occurred to me at once that a part of this sulphur might be in combination with lime as sulphate of lime. I therefore, in addition to the above work, examined two specimens with reference to how the sulphur existed in the coal.

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* And now known; see, farther on, the results of Professor Peckham's experiments. — (J. D. W.)

I used Julien's method for the determination of the specific gravities.* The coal was broken until the pieces would all pass through a sieve of thirty holes to the linear inch. From this the coarsest particles of nearly uniform size were separated and freed as nearly as possible from dust. From six to eight tenths of a gramme of this coal was weighed in a 100 grain sp. gr. flask, the flask nearly filled with distilled water, and allowed to stand at least twelve hours. The bottle was then filled and weighed at 62° Fahr., and the specific gravity estimated in the usual manner. Julien recommends a larger flask, but I found this more convenient, and sufficiently reliable for all practical purposes. The specific gravities are given in the table (p. 48).

Several facts of interest are brought out by an examination of these figures. The extremes are 1.7227 and 1.3043. The Eel River coals — Nos. 57 *a*, 57 *b*, and 57 *c* — are nearly alike in density, averaging 1.3662. The Monte Diablo coals — Nos. 59, 60, 61, 62 *a*, and 63 — have an average density of 1.3581; the extremes being 1.4150 and 1.3143. The average density of the twelve specimens of non-caking coals is 1.3759, the extremes being 1.4321 and 1.3143.

The determinations of sulphur were confined, for lack of time, to Nos. 51, 54, 56, 57 *b*, 59, 60, 61, 62 *a*, 63, and 68. These are the non-caking coals. They were made by the deflagration process, as follows. Two grammes of the pulverized coal were thoroughly mixed with sixteen grammes each of pure and dry nitrate of potash and carbonate of soda. The mixture was then projected by small portions at a time into a red-hot two-ounce platinum crucible. The fused mass after cooling was dissolved in water, transferred to a porcelain crucible, acidulated with pure hydrochloric acid, and evaporated to dryness to remove silica. The thoroughly dried residue was dissolved in water and filtered; the filtered solution heated to boiling, and the sulphuric acid precipitated with solution of chloride of barium. The sulphate of baryta was then collected on a filter, thoroughly washed, ignited, and weighed. All of the analyses were made in duplicate. The results corresponded very closely, the difference being but a small proportion of the whole amount, excepting in those cases where the percentage of sulphur was less than one per cent. The results were as follows: —

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* American Chemist, I. 460.

No. 51 (Bellingham Bay),	.544 per cent.	No. 60 (Union Mine),	4.466 per cent.
" 54 (Coos Bay),	.432 " "	" 61 (Stewart's Mine),	4.784 " "
" 56 (Corral Hollow),	3.452 " "	" 62 *a* (Clark Bed),	5.282 " "
" 57 *b* (Eel River),	3.135 " "	" 63 (Black Diamond),	4.045 " "
" 59 (Black Diamond),	4.979 " "	" 68 (Seattle),	a trace.

The Monte Diablo coals contain a large percentage of sulphur, averaging 4.711 per cent. Nos. 51 (Bellingham Bay), 54 (Coos Bay), and 68 (Seattle) are remarkably free from sulphur. The portions subjected to analysis were in each case taken from about twenty grammes of the pulverized coal, which had been knocked off from all sides of the specimens.

From a comparison of the analyses of the Monte Diablo specimens it will be seen that the analysis of a single specimen from a given locality does not furnish reliable data concerning the character of all the coal from that vicinity.

Having observed the great rapidity with which the matter volatile under 250° Fahr. was expelled and reabsorbed, I was led to infer that this volatile matter might be gaseous rather than aqueous. In order to test this, a tube was arranged to be heated in the air-bath. A drying-tube of ample dimensions was attached to one extremity, and to the other a small weighed drying-tube. When the air-bath was heated to 250° – 260° Fahr., and air drawn through the apparatus, the water appeared almost instantly in large quantity and collected in the small chloride of calcium tube. Nos. 57 *b*, 59, and 68 were examined by this method. The results were in each case from two to three tenths of one per cent above the results obtained by the method described in my former report. These experiments show conclusively that the volatile matter is all water, the slight excess being due to a trace of coal-dust carried over by the current of air.

A temperature of 300° Fahr. made no appreciable difference in the result.

In the case of No. 59 (Black Diamond), 82.59 per cent of the volatile matter was reabsorbed in about eighteen hours.

The ashes of the different coals were examined qualitatively in the usual wet way, and with the spectroscope. They all contained silicates of iron, aluminum, calcium, and sodium. No. 62 (Q. Charlotte Isl.) gave a trace of barium with the spectroscope. Nos. 56 (Corral Hollow), 57 *a*, *b*, and *c* (Eel River), contained sulphides. Nos. 57 *a*, 57 *b*, and 57 *c* also gave lithium with the spectroscope. No. 59 (Black Diamond) gave a trace of manganese. Phosphorus was sought in several instances in the residual solution after the sulphate of baryta had been precipitated, but without success. The amount of coal represented was two grammes. The reagent used was molybdate of ammonia. A trace of phosphorus, however, appeared, when .8325 grammes of the ash of No. 63 (Black Diamond) (representing 16.21 grammes of the coal) was subjected to the action of the same reagent.

No. 61 (Stewart's Mine) was tested in reference to its absorbent properties when acting on coloring matters. Three grammes of the finely pulverized and dried coal were digested with fifteen cubic centimetres of pure cider vinegar, and then filtered off. The vinegar was slightly decolorized. Three grammes of the coke of No. 61 (Stewart's Mine) was next tried, with slightly better results. A solution of raw sugar was not perceptibly changed in color. While the results furnished by these experiments were not such as to offer much encouragement towards a successful application of this substance in the arts, I would advise parties interested to make experiments upon a scale sufficiently large, and under such conditions as would thoroughly test its value in this direction.

In order to ascertain how the sulphur existed in the coal, four grammes of No. 62 *a* (Clark Bed) were digested in bisulphide of carbon, and the solution filtered off and evaporated. The residue was in appearance a resinous mass, that contained sulphur in considerable proportion. It was probably a hydrocarbon containing sulphur, or a mixture of sulphur with a hydrocarbon soluble in bisulphide of carbon. Four grammes of the same coal were digested in a boiling dilute solution of hydrochloric acid. The residue was filtered off and washed, and chloride of barium added to the boiling filtrate. As a result .0583 grammes of sulphate of baryta were obtained, equivalent to .2 per cent of sulphur, or .5 per cent of anhydrous sulphuric acid. A second portion of four grammes was treated in the same manner, and the lime precipitated as oxalate from the hydrochloric acid solution. As a result, .1082 grammes of caustic lime was obtained, equivalent to 2.705 per cent. This experiment was not repeated for want of time. These results would indicate that there was lime in the coal not in the condition of sulphate, as .1082 grammes of lime would require .1544 grammes of anhydrous sulphuric acid to form sulphate of lime, or about three times the amount obtained. It is not safe, however, to place much dependence on the results of a single analysis. The lime contained a trace of iron.

A single quantitative analysis of the ashes of No. 63 (Black Diamond) was made. They were found to be almost entirely soluble in hot hydrochloric acid. There was a slight effervescence during solution, and escape of sulphuretted hydrogen gas, which was not estimated. The insoluble residue was filtered off, washed, and weighed. It amounted to 8.768 per cent. The iron and alumina were next precipitated together, and were washed and weighed as anhydrous sesquioxides. There was only a trace of iron. The amount of both oxides was 3.902 per cent. The lime was then precipitated as oxalate; the precipitate washed and ignited. The amount of caustic lime obtained was 36.816 per cent. The sulphuric acid was then precipitated as sulphate of baryta, washed, dried, ignited, and weighed. The amount obtained was 43.627 per cent of anhydrous sulphuric acid, equivalent to 17.451 per cent of sulphur. Tabulated, the results were as follows: —

Insoluble matter,	8.768	per	cent.
Iron and alumina,	3.902	"	"
Anhydrous sulphuric acid,	43.627	"	"
Lime (CaO),	36.816	"	"
Total,	93.113	"	"

.3065 grammes of lime would require .4378 grammes of sulphuric acid (SO_3) to form sulphate of lime. The amount of SO_3 obtained was .3632 grammes. It is probable that a portion of the sulphate was reduced to sulphide, as sulphuretted hydrogen escaped when the ash was acted on by hydrochloric acid. This reaction could not have been caused by the presence of sulphide of iron, as the ash was almost pure white in color, and contained only a trace of iron. We may therefore conclude that all of the lime was in combination with sulphuric acid, which would represent 1.08 per cent of sulphur, not quite one fourth of the total amount present in the coal. In the absence of iron, it is interesting to inquire in what form the remaining three fourths of the sulphur appears in the coal, — a form in which so large a proportion as three fourths is volatilized during its combustion. This research was not repeated, and therefore not wholly to be relied upon.

In closing this report, I would remark that while Nos. 51 (Bellingham Bay), 54 (Coos Bay), and 68 (Seattle) contain a large amount of water, the two latter contain a small percentage of ash, and their remarkable freedom from sulphur must render them exceedingly valuable coals for many purposes in the arts where a sulphurous coal is more or less objectionable. The Monte Diablo coals, considered with reference to the large percentage of moisture and sulphur that they contain, are not very valuable coals.

TABLE OF ANALYSES OF PACIFIC COAST COALS.

Nos.		Locality.	Specific Gravity.	Volatile under 250° (water).	Volatile under white heat.	Fixed carbon.	Total combustible.	Ash.
59	California.	Black Diamond, Monte Diablo *	1.4150	13.015	42.15	34.235	76.385	10.600
63		" " " " †	1.3491	13.08	42.93	38.855	81.785	5.135
62*a*		Clark Bed, " " ‡	1.3539	11.64	45.67	34.555	80.225	8.195
60		Union Mine, " " §	1.3143	11.56	47.365	34.43	81.795	6.645
61		Stewart's Mine, " " ‖	1.3613	12.82	46.915	53.59	80.505	6.675
56		Corral Hollow, Alameda County	1.4321	15.015	41.435	30.805	72.240	12.745
57*a*		Eel River, Mendocino County	1.3596	8.14	45.54	38.67	84.210	7.660
57*b*		" " " "	1.3571	8.595	47.315	37.485	84.800	6.605
57*c*		" " " "	1.3820	8.555	48.51	37.88	86.390	5.055
51	Pacific coast, north of Cal.	Bellingham Bay	1.4151	7.375	39.85	38.655	78.505	14.120
52		Nanaimo, Vancouver Island	1.3492	2.795	43.125	42.055	85.180	12.025
53		Comox, " "	1.3401	2.015	32.73	56.14	83.870	9.115
62		Queen Charlotte Island	1.6781	1.18	17.25	49.835	67.085	31.735
54		Coos Bay, Oregon	1.4150	9.13	36.51	46.705	83.215	7.655
65		Nanaimo, New Co., Rosenfeld and Birmingham	1.3144	3.565	40.195	56.54	90.735	5.750
68		Seattle, Washington Territory	1.3919	13.85	38.375	41.74	80.115	6.035
53	Foreign.	Lata, Chili	1.3043	3.545	43.885	43.915	87.800	8.705
66		Saghalien, North Pacific	1.3136	1.925	36.61	52.80	89.410	8.665
67		Los Bronces, Mexico	1.7227	7.38	4.005	85.385	89.390	3.230
64		Sydney, Australia (Wall's End)	1.3471	3.01	31.165	55.56	86.725	10.265

*** From west face Counter Gangway, between Upper Black Diamond and Lower Black Diamond Gangways.**

† From west face Lower Black Diamond Gangway.

‡ Main Gangway, west face.

§ Present lowest gangway.

‖ Breasts 300 feet above West Gangway. (All collected by W. A. Goodyear in 1870.)

F.

EXAMINATION OF THE BITUMINOUS SUBSTANCES OCCURRING IN SOUTHERN CALIFORNIA.

By S. F. PECKHAM.

PART I. GEOLOGICAL AND HISTORICAL.

(JUNE, 1866.)

To speak seriously of the "Oil Interests of Southern California" draws forth from the majority of the citizens of this State a smile of incredulity or ridicule. To urge their claims to consideration as a field for profitable investment presents to most men strong reasons for doubting your sanity. Yet the southern portion of this State has veritable oil interests, which only need the fostering care of men of sound judgment, aided by sufficient means, to enable this section to ultimately furnish this entire Pacific Coast with both illuminating and lubricating oils, at prices that will render futile all competition of Eastern products.

Such are the facts as they exist to-day; but, at the same time, with the great mass of this community, and, it may be said, with that of the entire country, so far as it has at any time received attention, this interest was never more depressed in commercial value than at present. The only reason that can be assigned for such an anomalous condition is the fact that real merit has been obscured and rendered contemptible by excessive falsehood and exaggeration, and that a natural production, capable of profitable development, has been made an object of distrust and suspicion by false definitions and spurious representation.

To convey an impression that will bear the test of comparison with facts, and to assist, so far as I may be able, in giving a valuable interest its true position among the vast number of resources with which nature has so lavishly furnished this State, is the object of this report.

To geology and commerce this subject is alike interesting, and there are few instances in which science can bring to the latter more signal aid. I consider a correct general idea of the formation and superposition of the rocks containing the various qualities of bitumen to be indispensable, in order to insure a judicious expenditure of capital in the development of this interest. My observations have extended over that portion of the State which is at present yielding the largest amount of valuable products, viz. from a few miles east of Point Conception, where bitumen is found floating upon the sea, to the Cañada de Brea, below Los Angeles. The distance between these localities is, in a right line, about one hundred and fifteen miles, and, following the strike of the bitumen-bearing rocks, about one hundred and forty miles.

Bitumen is the generic name by which all the varieties of asphaltum, maltha or mineral tar, petroleum or mineral oil, naphtha, brea (Spanish), etc., are known in science. Every variety, except naphtha, is found in this region, and, in speaking of its general geological features, I shall make use of this generic term.

The geological formations throughout this region are of the Miocene age. They consist of conglomerates, containing pebbles of igneous rocks, red, drab, and yellow sandstone, slates, shales, and clays; the different varieties so mingled and passing into each other as to present a vast number of gradations, from impure porcelain clay to sandstone without sufficient clay to prevent its rapid disintegration. In certain localities deposits of limestone occur of considerable extent, and carbonate and sulphate of lime are often found in small quantities, mingled with the clay and sand. Immense masses of tufa are deposited in many localities by mineral springs, and free sulphur is found in small quantities.

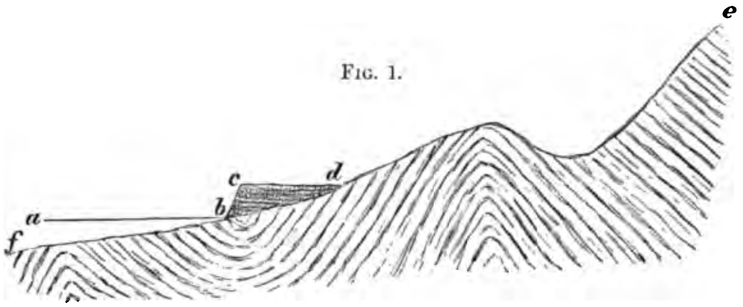
The source of the bitumen is invariably found to be a bluish slate or shale, more or less firmly indurated, and containing a variable proportion of fine quartzose sand. This rock, when mined and suddenly exposed to atmospheric influence, in the majority of instances, rapidly disintegrates, and becomes, when wet, a mixture of plastic clay and sand. It also contains more or less protoxide of iron, which causes it to weather of all shades, from dirty white to brown, and, when metamorphosed by heat, to assume, by peroxidation of the iron, all the shades of ochre and brick-red. Bitumen is sometimes seen issuing from crevices in sandstone, but, in such instances, underlying or overlying strata of argillaceous rocks are invariably its original source. Bitumen is not always found where rocks possessing these mineralogical characters are exposed, but the presence of bitumen invariably indicates such rocks as its source. Sandstone, *per se*, is in no instance that has come under my observation an indication of the proximity of bitumen.

The outcrops of bitumen throughout this region are mainly confined to a belt extending from a few miles east of Point Conception almost due east to the San Fernando Pass in Los Angeles County, and thence running from ten to fifteen degrees south into San Diego County. This belt indicates the position of the former crest of one of the immense undulating waves into which this formation has been thrown, forming the Coast Ranges and the foot-hills upon and near their southern slopes. This crest was not originally level, but exhibited great variations in altitude; such variations, however, bearing no relation to the present lines of elevation throughout this section.

Three great physical forces have united in giving to this region its present conformation of surface. These are earthquakes, the erosion of submarine currents, and the effects of rains alternating with protracted drought. In the absence of long-continued observation, it is impossible to assign to each of these agencies the particular phenomena produced by them; but it is without doubt to the effect of submarine currents that the most prominent features of the present landscape owe their origin; and to this cause the varying conditions of exposure of the bitumen-bearing rocks are almost without exception due.

East of Point Conception, bitumen is first observed floating upon the sea; its source, doubtless, Miocene rocks, standing at a high angle, their upturned edges forming the bed of the ocean. On shore to the north of this point, the bluff consists of Pliocene, or Post-pliocene, semi-indurated sand; slightly undulating upon the sea-wall, and dipping north about ten degrees. The sandstones and shales again appear in the Santa Iñez Mountains and foot-hills, about six miles to the north. The annexed section (Fig. 1), a part of which is ideal, illustrates the supposed position of these rocks.

FIG. 1.

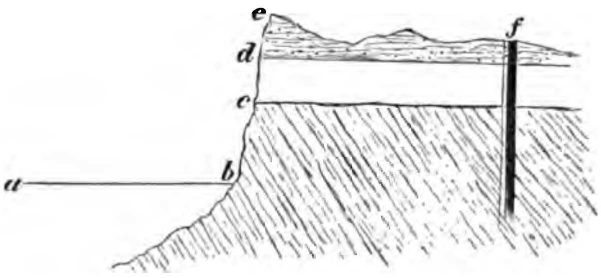


SECTION NEAR POINT CONCEPTION.

a b, sea level; *b c d*, Post-pliocene bluff; *f d e*, supposed conformation of shale formation.

Nine miles east is the town of Santa Barbara, near which the same geological features are observable. A short distance east of the town the bitumen-bearing belt strikes the shore. Fifteen miles east at Rincon Point upon the ranch owned by Dr. Biggs, the overlying Pliocene formation is saturated with bitumen. The annexed section (Fig. 2) exhibits the relation of these formations.

FIG. 2.

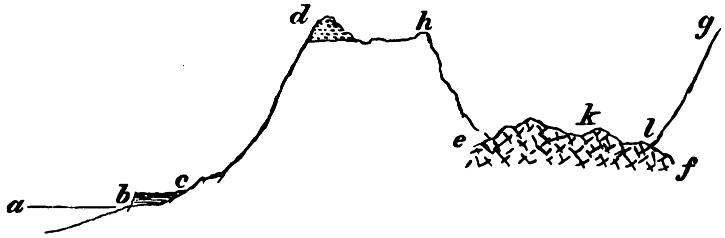


SECTION OF BITUMINOUS ROCKS ON BIGGS'S RANCH.

a b, sea level; *b c*, bituminous shale; *c d*, unstratified sand saturated with bitumen; *d e*, soil; *f*, well recently commenced.

Five miles east of the house of Dr. Biggs this ancient elevation attained its greatest altitude. The low hills at this point consist of sandstones metamorphosed dark red, their crests about one thousand feet above the sea level. In the cañons of the southern slope of the Santa Iñez Mountains, to the north of these hills, I am informed that outcroppings of bitumen of small extent are observed, the mountains themselves consisting of shale weathered white. South of these hills, Mt. Hoar and the chain of lower hills reaching to the San Buenaventura Valley attain an altitude of from eighteen hundred to two thousand feet. The strata contiguous to the sandstone consist for the most part of shale, and outcroppings of bitumen of small extent have been observed in the cañons cutting this range. The point at which these hills touch the San Buenaventura Valley is about six and one half miles from the coast, and twenty-five miles east of the town of Santa Barbara. Between the bituminous outcrops of this range and the coast Miocene sandstones and argillaceous rocks form undulations, none of them of sufficient altitude to bring the bituminous strata to the surface. A section about one mile east of the Willow Cañon, equidistant from Rincon Point and San Buenaventura, exhibits the relations of the metamorphosed strata to the formations upon the north and south.

FIG. 3.



SECTION NEAR WILLOW CAÑON.

a b, sea level ; *b c*, Post-pliocene, semi-indurated sand ; *d*, Pliocene gravel, lying unconformably upon Miocene argillaceous sandstones ; *i d h e*, Miocene rocks in undulations ; *e k f*, metamorphosed sandstone ; *f l g*, Miocene rocks. Bitumen appears in cañons beneath *h* and *g*. Distance from *b* to *g* thirteen miles.

Upon the eastern slope of this crest of metamorphosed sandstone lies the Santa Ana Ranch. Shales appear in the bluffs along the western border of the San Buenaventura River. Crossing the river, shales appear in the opposite bluffs, covered with an accumulation of gravel, often fifty feet in thickness. This gravel is often met with in this section, and is a mixture of sand, pebbles, and boulders of from three to eighteen inches in diameter. The pebbles are mostly of igneous rocks, from disintegrated Miocene conglomerates, and the boulders fragments of Miocene sandstone rounded by erosion. Shale more or less deeply imbedded in gravel forms the triangular tract lying between the San Buenaventura River and San Antonio Creek, upon which no bitumen has been discovered.

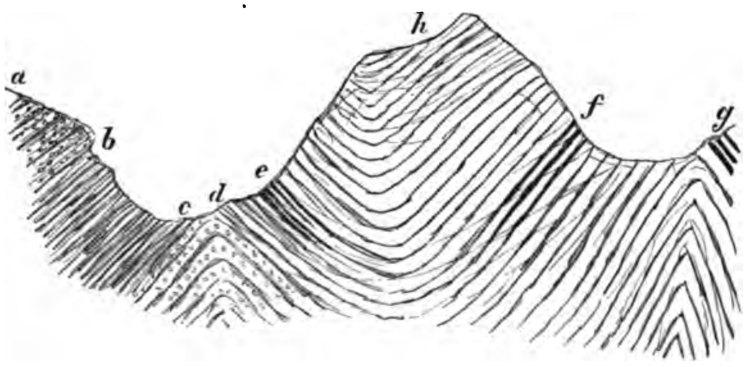
Opposite the point at which the Mt. Hoar range reaches the San Buenaventura River, the slopes of the southwestern extremity of the Sulphur Mountain are met. The crest of this range bears northeast about seven miles, and thence east for about the same distance. At the apex of the angle formed by this range is its highest point of elevation, about 2,000 feet above the sea. At the base of this spur, upon the southern slope, lies the Cañada Larga. West of this point the crest of the mountain is depressed and cut by cañons causing the crests of the divides between them and that of the main range to resemble the palm of an outstretched hand. To the northwest a spur of metamorphosed sandstone pierces the overlying shale. For about three miles east of this point the crest of the mountain remains unbroken.

Beyond it is cut by cañons opening into the valley of Ojai for about two miles, and then remains unbroken to its eastern extremity. From the Cañada Larga east the southern slope of the Sulphur Mountain is cut by five large cañons extending to the Santa Clara Valley. All of these cañons on both sides of the Sulphur Mountain contain bitumen. The basin of Ojai (so called) is an elevated valley, about three miles in length, lying between the eastern half of the Sulphur Mountain and the foot-hills of the Santa Iñez Mountains. Upon a plateau at the eastern extremity of this valley the celebrated "Big Spring" is situated, with several other minor outcrops of bitumen.

If, from the outcropping of bitumen on the northern boundary of the Santa Ana Ranch, in the cañons of the southern slope of the Santa Iñez Mountains, we cross the San Buenaventura River and the low shale hills covered with gravel between that river and the San Antonio Creek, we meet the bituminous strata again, and find a very extensive outflow in a bluff, forming the western boundary of the basin of Ojai. This line may be traced in very copious outcrops from this point across the plateau which forms this basin to the eastern extremity of the ranch.

From San Buenaventura to the embouchure of the Cañada Larga, the Miocene sandstones and conglomerates form an immense undulating wave, the bituminous strata not being elevated to the surface at any point. A synclinal basin appears a few hundred yards north of the old aqueduct, at the mouth of the cañon, beyond which sandstones, conglomerates, and argillaceous rocks appear dipping south with unbroken regularity for a distance of two and one half miles in a right line. The shales are there met with dipping south, and beyond them an anticlinal crest of coarse conglomerate appears, with bituminous shales lying upon its northern slope dipping north. The Sulphur Mountain is formed entirely of shale. The bituminous belt passes through the mountain and appears upon the opposite side dipping south, and forming a synclinal fold. This fold may be traced from the Cañada Larga Spring to the eastern extremity of the Sulphur Mountain. The same shales appear along the border of the basin of Ojai dipping north. The annexed section (Fig. 4), from a short distance south and east of the Cañada Larga Spring to the foot-hills of

FIG. 4.



SECTION ACROSS THE OJAI RANCH.

a b, sandstones; *b c*, non-bituminous shales; *c d*, anticlinal crest of conglomerate; *e h f g*, shales; *e f g*, outcroppings of bitumen.

the Santa Iñez Mountains, which form the northern boundary of the Ojai Ranch, will show the position of three lines of outcrop at this point. The distance in a right line is about two and one half miles.

The synclinal fold does not appear to belong to the entire formation, but to be confined to the more yielding shales. This section gives a correct general idea of the structure of the Sulphur Mountain, from the Cañada Larga east.

Crossing the Mupu Creek and Santa Paula Cañon, the highest peak in the range forming the northern border of the Santa Clara Valley is encountered. Its elevation is about five thousand feet. Its structure is a combination of that of the Sulphur and Santa Iñez ranges, of which it forms the junction. I have been unable to learn that bitumen has ever been discovered upon either the northern or southern slope of this peak.

At the eastern slope of this peak runs the Sespe Creek through the Sespe Cañon. The stratification at this point is very much broken, bitumen-bearing shales appearing upon either side of a high spur of metamorphosed sandstone. The most extensive outcrops occur in a high valley to the north, distant from the mouth of the cañon about five miles. They are reached by passing over the anticlinal of metamorphosed sandstone, beyond which the ascent is made over steep ridges and deep cañons, across fossiliferous strata of fine conglomerate and sandstone; non-bituminous shales next appear, overlain by the bitumen-bearing strata, consisting of shales and sandstones, through the crevices of which the bituminous material filters. Above, the overlying non-bituminous shales form the steep sides of cañons reaching to the crest of the mountain, which consists of yellow sandstones sloping to the northeast. The underlying non-bituminous strata of shale are interstratified with metamorphosed, highly fossiliferous strata of sandstone, a few inches in thickness. I know of no locality where the relative positions of the different strata are better exposed.

East of the Sespe Cañon is the Cerco Cañon, in which are quite extensive exposures of bituminous strata, and still farther east is the Piru Cañon with like exposures.

At the Piru Cañon the bituminous strata cross the Santa Clara Valley. They are again met nearly opposite, at an elevated exposure that occurs in a cañon at the southwestern extremity of the San Francisco Ranch. The crest of the upheaval extends in a right line from this cañon, to a point about one mile south of the toll-house at the San Fernando Pass. The bituminous rocks here are less elevated above the surrounding country than at points farther west, although its general altitude of from eight to fifteen hundred feet above the sea continues throughout its whole extent. The exposures of shale are entirely due to erosion; the overlying sandstone being cut through by deep cañons, laying bare the shales upon their sides and in the barrancas formed within them.

From the San Fernando Pass to the hills at and around Los Angeles, and farther to the southeast into San Diego County, similar exposures occur in many localities. Those most remarkable for their extent are found upon the plain and low hills to the southwest of the town of Los Angeles, where the overlying sandstones have been cut down to the bituminous rocks. I am of the opinion that these exposures belong to an anticlinal crest, lying to the south of the main crest or belt that we have been tracing, an outcrop from which I am told has been discovered upon the Rancho Las Posas, fifteen miles southeast of the town of San Buenaventura.

East of the San Fernando Pass igneous rocks are protruded through the Miocene strata. Several varieties of granite, mica schists, and gneiss are here seen near the summits of the mountains; the sandstones, conglomerates, and shales lying upon their sides conformably with the metamorphosed strata.

Sandstone containing fossils of Miocene age has been observed in many localities contiguous to the bituminous shales. These fossils consist of cetacean bones, and a great variety of marine shells. Very few fossils have been found in the shales. One locality of small extent upon the bank of the San Buenaventura River was discovered by myself to be rich in a small variety of shell, pronounced by Mr. Gabb to be a new species of Pecten.[×] In a tunnel recently opened upon the Ojai Ranch, obscure remains of several species of shells were found, and in an excavation upon the Moore claim near the San Fernando Pass, I was told that cetacean bones were discovered in shale saturated with maltha. At the time I visited this locality this excavation was filled with water.

Such are the general geological features of the region embracing the Oil Interests of Southern California.

Before attempting any description of the different exposures of bitumen and their relative value, I wish to furnish such definitions of the terms that I shall employ, and such explanation of the causes which produce bitumen in different forms, as will render my meaning clear and prevent misunderstanding.

Bitumen exists in many parts of the world, and occurs in an almost endless variety of forms. These are chiefly included in four great classes, viz. Asphaltum, Maltha, Petroleum, and Naphtha.

Dana speaks of asphaltum as the "hardened variety of bitumen, often breaking with a high lustre like hardened tar," and of maltha, or mineral tar, as "a less fluid variety than petroleum." Subsequently he remarks that petroleum is common in the United States, being found at Oil Creek, Venango County, Pennsylvania.[*] Dr. Ure, describing the varieties of bitumen, says, "*Asphaltum* is solid..... There are also the earthy or slaggy *mineral pitch*; — *petroleum*, a dark-colored fluid variety, containing much naphtha; and *maltha*, or *mineral tar*."[†] For a more detailed description of varieties of bitumen, see Watts's Dictionary of Chemistry, Vol. I. pp. 425 and 600.

Their chemical constitution is a compound of carbon and hydrogen, with a variable proportion of oxygen, nitrogen, and sulphur, as they occur in this region.

The value of bituminous minerals depends in commerce not so much upon chemical constitution as upon certain physical properties. The first three varieties alone are found in this section, — the first in vast quantities and over a large extent of country, the third variety at only three or four natural outcrops, widely separated. Only the petroleum and the lightest varieties of the maltha have thus far been proved to be of economical value.

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[*] Manual of Mineralogy (ed. 1864), pp. 95. 96.

[†] Ure's Dictionary of Arts, Manufactures, and Mines (ed. 1863), Vol. I. p. 308.

[×] Named by Prof. Gabb – Pecten Peckhami.

At the present time — at least, upon this continent — the hydrocarbon mineral oils procured in Pennsylvania furnish a type, with which all other mineral products of similar character are compared commercially. The Pennsylvania oils, it will be observed, are designated by Dana as petroleum, and by that name they are known throughout the commercial world. I have met no more terse or comprehensive definition of the word "petroleum" than that made use of by Professor W. H. Brewer, formerly of the Geological Survey of this State. He says: "As I understand it, petroleum is the term used to designate certain mineral oils which do not absorb oxygen and go through other spontaneous changes in free contact with air, so as to harden into a solid mass readily." * This definition is not restricted to oils not susceptible of oxidation, but to those which do not oxidize *readily*. The oils of Pennsylvania do not change readily. The bituminous minerals of that region, which have up to this time been proved to be of value, or capable of manufacture into an article of commercial value, are unchanged, and are not *readily* susceptible of change. No one familiar with the physical properties of *oil* and *tar* will fail to recognize at once the difference between the unchanged or slightly changed petroleum, or rock-oil, and the black, viscid maltha, or mineral tar. I am thus explicit in definition, because any confounding or interchange of these terms cannot fail to become a source of error.

Although very considerable quantities of petroleum are now being produced in this region, none of this material has yet been discovered equal in quality to the best procured in Pennsylvania; and the manufacturers of these oils do not claim that the illuminating oils obtained from this source are equal to the best Eastern grades.

The recent developments by which artificial outflows of petroleum have been obtained, and the juxtaposition of natural outflows of these different varieties of bitumen, all prove most conclusively that they were all originally a light petroleum, impregnated with carburetted hydrogen gas. These light petroleums are invariably very mobile hydrocarbon fluids. They are dichroic, or green by reflected light and brown by transmitted light, and when fresh from the rock are highly inflammable. The influence of the atmosphere converts them, first, into a dark olive-green fluid of increased density; then into a dark brown oil, still more dense; then into a black, viscid tar, increasing in density and viscidity, until it becomes heavier than water, and finally solid black asphaltum, with a density of 1.170. The fact that the larvæ of insects are seen in the light petroleum and malthas proves the presence of nitrogen, which is essential to the support of animal life. The maltha is frequently borne to the surface upon water impregnated with hydrosulphuric-acid gas. Sulphur is often deposited from the water, and becomes mixed with the maltha and asphaltum. Water, hydrosulphuric-acid gas, and atmospheric air are often mechanically mingled with the maltha in considerable quantity. At the "Big Spring," upon the Ojai Ranch, copious evolutions of carbonic acid occur, and at many other springs the bitumen is accompanied by carburetted-hydrogen gas.

I have observed no evidence to prove that asphaltum and maltha are the residuum of petroleum, or the result of the inspissation of petroleum. On the contrary, the change is due to accretion of particles, or oxygenation. This is proved by the fact

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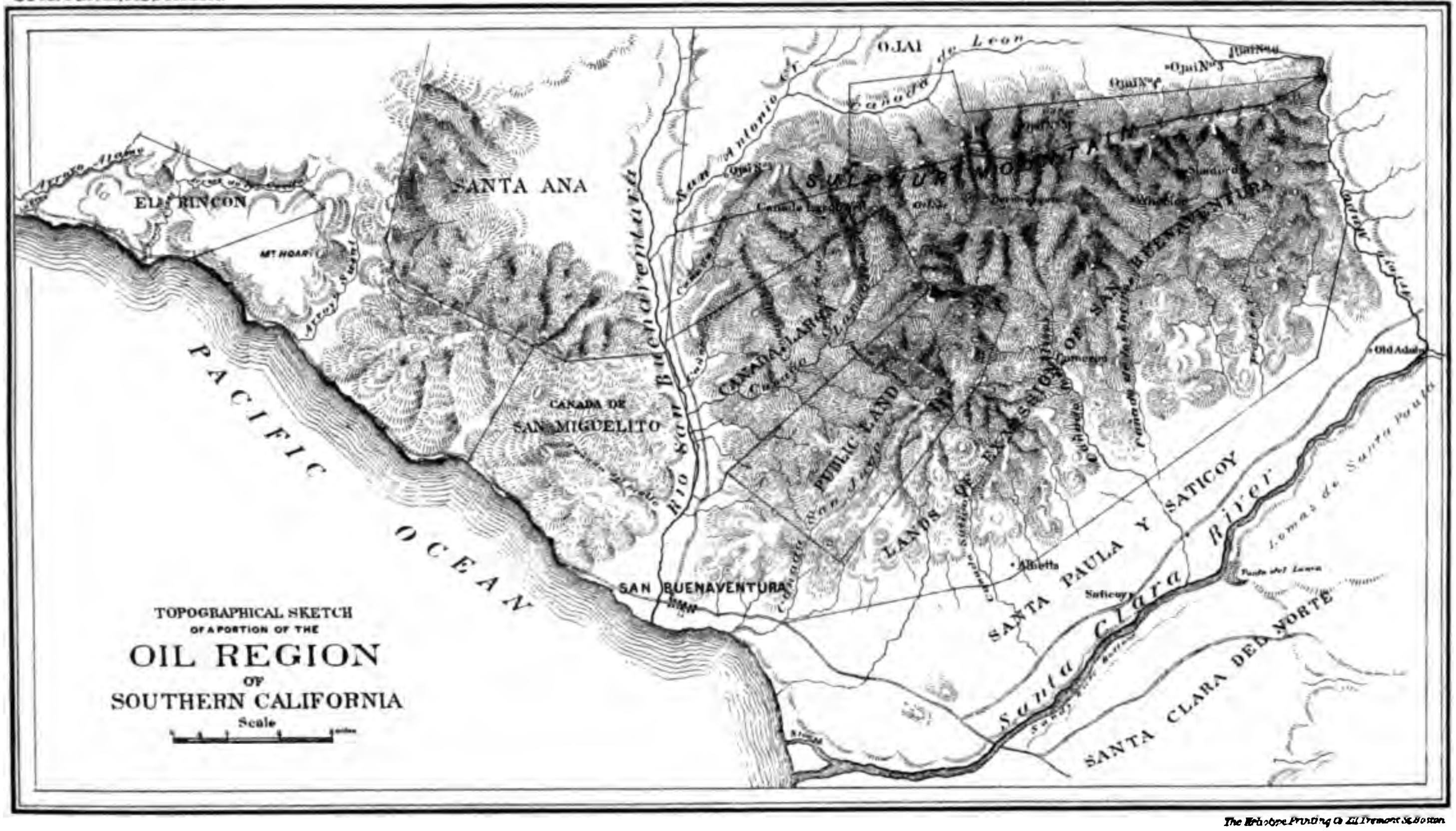
* Letter to Hon. D. L. Harris of Springfield, Mass.

Geol.Cal.II,Appendix. Plate B.



TOPOGRAPHICAL SKETCH
OF A PORTION OF THE
OIL REGION
OF
SOUTHERN CALIFORNIA
Scale

The Heliotype Printing Co. 211 Tremont St. Boston.

that vapor commences to form from oils taken from the extremities of tunnels more than one hundred feet in length, at a temperature far above that produced by the direct rays of the sun at its highest altitude. It is also proved by the fact that malthas of varying density have been produced at from ten to four hundred and sixty feet from the surface; the latter a depth too great to admit of the slightest action from the sun's rays. All the phenomena that I have observed throughout this entire region, without a single exception, whether it be difference of exposure, product, or mode of development, prove that the change from petroleum to asphaltum and maltha is due solely and entirely to atmospheric influence, either direct or transmitted by the agency of rain-water. Upon the facility with which rain-water can infiltrate bituminous strata, capable of being practically penetrated by either the drill or tunnel, depends the value of bituminous exposures as oil-producing properties.

No locality that I have observed furnishes so many fine examples of the different varieties of petroleum, maltha, and asphaltum, and the changes incident to difference of exposure of the oil-bearing strata, as the section known as the San Buenaventura Oil District. This district embraces, upon both sides of the Sulphur Mountain, the Ojai Basin (so called) upon the north, and the Webber and Thompson Cañons, Stanford Oil Springs, Hayward Petroleum Company's Springs, Bornträger's Cañon, and the Cañada Larga, upon the south.

The entire southern slope of this range is precipitous, and can be ascended on foot only with great difficulty. The oil shales appear in the Cañada Larga at several points. The exposure known as the Cañada Larga Oil Spring is in a very deep cut in the mountain, the sides of which are almost perpendicular, and where the overlying strata are from six to eight hundred feet in thickness. The other outcrops, which are all situated at the foot of gentle slopes, furnish maltha of different densities.

In Bornträger's Cañon small quantities of petroleum have been developed by tunnelling, but the outcrops are mostly low down, and the strata from which the maltha escapes are so exposed that the surface is nearly horizontal, and rain-water penetrates between the strata to such a depth as to affect the petroleum to a very considerable extent.

The next cañon east is the property of the Hayward Petroleum Company. In this cañon natural springs of petroleum occur, and also springs from which the bitumen issues of a dark olive-green color, soon changing to brown and becoming black and viscid after slight exposure. The side of the mountain at this point is very precipitous and the outcrops occur high up. Non-bituminous shales at least eight hundred feet in thickness overlie the oil-bearing rock, and the almost perpendicular mountain-side falls about three hundred feet below it. Where the springs of petroleum occur the sides of the cañon are steepest, and copious springs furnish a stream of water at all seasons to bear away the oil, and prevent its accumulation as maltha or asphaltum. Where the more dense varieties occur the cañon is less precipitous and but little water flows, consequently the bitumen accumulates and forms beds of asphaltum.

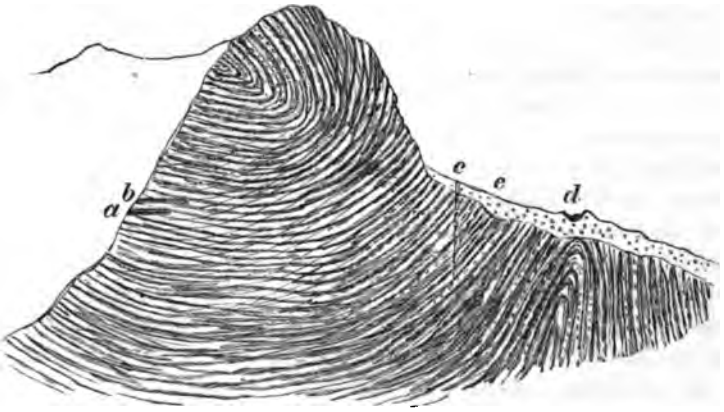
At the Stanford Oil Springs still farther east, the outcrops are lower and the conformation of the surface such that petroleum does not reach the surface, but is found only a short distance beneath it.

In the Webber Cañon, which is a cañada of the Santa Paula Cañon, outcrops of very dense petroleum or light maltha are found upon the mountain-side. It flows down and accumulates in beds of asphaltum. Below these is a copious outflow of light maltha, which issues from strata horizontally exposed in a gentle slope. The bitumen appears at this point of a dark brown color, and pits dug to a depth of twenty feet failed to produce petroleum.

Upon the Ojai Ranch, which lies upon the opposite side of the mountain, very copious outcroppings of bitumen occur under different circumstances of conformation of surface, and much more dense products are the result. A considerable outcrop of maltha occurs in the bed of the Mupu Creek, which flows past the entrance to the narrow valley which forms the eastern portion of the ranch. This maltha is black, fetid, and dense. It flows from strata dipping at a high angle, the upturned edges of which are exposed horizontally over a large area, elevated but a few feet above the outcrop. Passing up the valley before mentioned we have the Sulphur Mountain on the left, its summit about thirteen hundred feet above the bed of the stream, and on the right a range of low foot-hills of the Santa Iñez Mountains. There are no outflows upon the Sulphur Mountain for a distance of two and one half miles, when the plateau or "basin" of Ojai is reached by an abrupt ascent of about two hundred and fifty feet. Upon the foot-hills, at an elevation of about one hundred and fifty feet at their eastern extremity, constantly decreasing as we ascend the valley, are copious outflows of maltha of varying density. A plateau one hundred and fifty feet above the outflows exposes a large horizontal surface to infiltration of rain-water, consequently bitumen appears upon the surface in the form of maltha. Opposite the property of the Hayward Petroleum Company is the "Big Spring" and the plateau surrounding it. The entire mountain and plateau consist of shales through which runs a belt of bituminous rock.

The annexed section illustrates the difference of exposure, and consequent variety of surface product, upon the opposite sides of the mountain at this point.

FIG. 5.



SECTION OF SULPHUR MOUNTAIN.

a b, tunnels, producing light petroleum, only one hundred feet in length; *c*, well No. 3 on Ojai Ranch; *d*, "Big Spring." Outflows of very thick maltha occur between *e* and *d*.

The springs and tunnels at *a b* pierce strata exposed with a perpendicular face, with which rain falls nearly parallel and fails to penetrate it. Upon the north side the bitumen escapes between *c* and *d*, from strata exposed horizontally, and passes through gravel to the surface. The oil-bearing shales upon the south side are protected by the mountain above them; on the north side rain falls perpendicular to the exposed surface, and penetrates the shales to an immense depth. On the south side the oil is delayed in its passage only a few months or days, and issues unchanged or slightly changed petroleum; on the north side it is delayed for months or years, and issues a thick, heavy maltha.

Near Los Angeles, in strata similarly exposed to those upon the "Big Spring" plateau, an artesian boring produced maltha, at a depth of four hundred and sixty feet.

Shafts, tunnels, and artesian borings have been employed for the purpose of obtaining petroleum. Shafts have been used but sparingly, and might perhaps in those few instances be more properly called pits. In the greater number of localities where this method has been adopted, a better quality of maltha has been procured than that upon the surface, and in one or two instances petroleum has been found; but it is not made use of by those who have been most successful in obtaining oil.

Tunnels in localities favorable to their use have been found to be the most productive, and are in fact at this time the only productive means of obtaining petroleum. They require an exposure of the oil-bearing rock so nearly perpendicular that unchanged petroleum may be reached at a short distance from the surface. They necessitate only manual labor without expensive apparatus. They expose a large surface to leakage, and therefore furnish a greater amount of oil. They penetrate rock that is not susceptible to percolation by rain-water, often many hundred feet below the horizontal surface. They enable the operator to gather small quantities of oil without the expense of pumping. When once in successful operation they furnish a continuous flow of oil, at little cost current, and promise a moderate yield for a long period. The opportunities for successful tunnelling are few, however, when compared to the large number of bituminous outcrops throughout this region.

Artesian borings have, in no case that has come under my observation, promised success, when compared with operations in the East, or with the results furnished by tunnelling in favorable localities. The formation which contains the bituminous minerals of this region is an indurated clay in very thin strata, frequently so cross-fissured as to render the line of stratification doubtful, and often subject to disintegration beneath the surface, when disturbed in contact with water. It is generally too firmly indurated to admit of the possibility of boring with an auger, or when piped of being cut by the lower edge of the instrument. As a consequence, drilling, reaming, and piping the entire distance penetrated is the only method of operation to prevent caving, and consequent clogging of the well by buried tools. In one or two instances where shale is interstratified with strata of sandstone, wells have been put down to a considerable depth without piping. To overcome these difficulties has required much time and great expense, on the part of all parties who have attempted deep boring.

No attempt has thus far produced a flowing well, and many have failed to produce bitumen of any description, while others have yielded malthas at various depths. In one single instance, I am told, petroleum was struck at a depth of fifty feet, where the well was located near a spring yielding that substance.

I consider it impossible that flowing wells, in the sense in which that term is used in the Eastern States, can ever be obtained in this section. No evidence has yet come under my observation to lead me to suppose that cavities of any considerable extent, containing oil, can exist in the bituminous shales of this formation. Where shales are interstratified with sandstone small cavities may occur. The shales are so cross-fissured that the gases with which the oils are impregnated do not accumulate, but readily find their way to the surface. Where large subterranean pools of oil do not exist, and gases escape through numerous fissures, I can see no reason why oil should be driven to the surface at any one point in any considerable quantity.

The oil appears to be held, by capillary attraction, between the strata and within the crevices of the shales. An artesian boring at the base of the hills only pierces the outside shales that were long since exhausted of their bitumen, or in which oxidation has transformed it into maltha or asphaltum. In the majority of instances throughout the San Buenaventura District, the bases of the hills are geologically below the oil-bearing strata. A well among the hills only exposes to leakage a surface equal to the circumference of the orifice multiplied by the depth of strata pierced, — a small surface, when compared with that exposed by a tunnel. These facts account for the small amount of maltha that a few wells are now yielding.

Should any of the wells now being bored be sunk to a sufficient depth to reach unchanged oil, I venture the opinion that they will yield, on being pumped, a long-continued flow of oil in very moderate quantity.

Tunnelling offers at present far greater inducements than any other method of operation upon those properties where it is at all practicable.

I shall now proceed to give a detailed description of the outflows and properties being operated upon for oil, in accordance with the above facts and definitions.

While sailing down the Santa Barbara Channel in August last, I observed that the substance which has been observed for so many years floating upon the sea was maltha. The wind was blowing fresh at the time, and directly up the channel. It blew the maltha into a sort of windrow extending from the coast above Santa Barbara towards Santa Cruz Island. The sea was iridescent upon one side, upon the other clear, the windrow of brownish-black maltha lying between. The bituminous strata here form the bed of the sea, where the water is not of very great depth. Sea-water, always containing near the surface atmospheric air, penetrates the crevices of the oil-bearing rocks, and causes the oil to become light maltha, which rises to the surface. It then spreads into a thin film, becomes gradually oxidized into soft asphaltum, and is thus thrown on to the beach above and below Santa Barbara. Various schemes for procuring petroleum from this source have been proposed, but no attempt has yet been made to carry them into effect.

At La Goleta, nine miles west of Santa Barbara, there is a bluff along the sea-beach sixty feet in height. This bluff, of semi-indurated Pliocene or Post-pliocene sand, without doubt once extended seaward for a long distance beyond its present verge. Immense fissures, some of them extending from the base to the crest of the bluff, appear filled with solid asphaltum, apparently of very pure quality. This formation is probably underlaid by Miocene oil-bearing rocks, from which maltha oozed at some former period, and accumulated beneath the overlying sand. An earthquake or the disruptive force of pent-up gases has evidently rent the superimposed strata, and forced the plastic bitumen into the fissures, where it has hardened into asphaltum. Some of the veins are at right angles to the beach, others are parallel with it, and they are of varying width and extent. Five or six miles west of this place is an ancient sea-beach, elevated about thirty feet above the present high-water mark. Deposits of asphaltum are found upon it in irregular masses, very impure from admixture of sand and shells. Both these deposits have been profitably worked by Mr. Thomas Moore. The asphaltum is simply cut of convenient size, and shipped to San Francisco, where it is used for roofing and pavements. The admixture of sand which these asphalts contain, I am told, renders them especially valuable for these purposes.

An artesian boring was commenced upon the Hill Ranch, about three miles from the beach. I am told the work was not prosecuted beyond a depth of eighty feet, but I have been unable to learn why it was suspended.

Ancient beds of asphaltum mixed with sand and shells are found among the low hills northeast of the town of Santa Barbara. I have been unable to determine whether they are the product of exhausted springs of maltha, or the accumulations upon an ancient beach from springs beneath the ocean. I am told that outcrops of maltha of small extent are found among the foot-hills of the Santa Iñez Mountains, back of Montecito and the Carpenteria.

Fifteen miles below Santa Barbara, upon a high bluff called Rincon Point, occurs a deposit of sea-sand, saturated with maltha, of very great extent. This deposit extends upon the sea wall between one and two miles, and is about twenty feet in thickness, overlaid with sandy soil from five to ten feet in depth. Fig. 2 (page 51) illustrates the position of these deposits. The sand lies horizontally and unconformably upon the upturned edges of Miocene shales, which stand dipping north at an angle of about 70° from the horizon. The crest of the shale is now about twenty feet above the present beach. A very dense maltha issues from fissures in the shale exposed upon the beach. This deposit appears to have accumulated when the shales now covered were a beach, from which the maltha oozed and mingled with the drifting, rolling sands.

An attempt was made some years since to procure merchantable oils from this source, by retorting the saturated sand, and subjecting the distillate to rectification. I have never seen any of these oils, but have been told the enterprise was not a pecuniary success.

During the past summer an artesian boring was commenced above this deposit, about one hundred yards from the verge of the bluff. I have been told by the gentleman who superintended the operation, that, after passing through five feet of soil, the bituminous sand was reached, which continued for twenty feet. The boring then passed through shale for fifty feet, at which point operations were suspended and have not yet been resumed. I believe that at this point unchanged petroleum can be reached only at a very great depth.

Near the summit of Mt. Hoar a spontaneous evolution of heat occurs in connection with an evolution of maltha. I am told that at a few points among the hills forming this range, west of the San Buenaventura River, springs of maltha and deposits of sand saturated with bitumen are found. In the deep cañons of the Santa Iñez Mountains, north of the Santa Ana Ranch, I am told several springs of "green oil" have been discovered. The location of these springs is in an almost inaccessible cañon. No steps have been taken towards the development of either of these outcrops.

On the east side of the San Buenaventura River, from near the embouchure of the Cañada Larga to that of the Cañada Matilija, and eastward between the Sulphur and Santa Iñez Mountains to the Mupu Creek, lies the Ojai Ranch, at present the property of the California Petroleum Company. Upon this property is found more asphaltum than upon any other of equal extent in this region. I should think perhaps a hundred acres were covered to a depth varying from two to thirty-six inches. It is, however, generally quite impure, being mixed up with from ten to ninety per cent of grass, leaves, driftwood, and disintegrated soil and rock. It is too far from shipping to successfully compete with that taken from localities nearer the coast, and is more impure than that procured at La Goleta. Besides these extensive deposits of asphaltum, from twenty-five to thirty springs of maltha are found upon this property, varying in specific gravity from .946 to .985, and in one or two instances it occurs heavier than water.

These malthas were worked, a few years since, by Mr. Gilbert of San Buenaventura, in a refinery of quite limited capacity. I am told his results were variable, and not on the whole a pecuniary success. A sample of his burning oil that I have seen would not at present command a sale. I am of the opinion that a lubricating oil of good quality can be made from the malthas with proper methods of manipulation, but their manufacture has not yet been made successful. The aggregate quantity yielded by the springs is very small, and the material is very difficult to handle in consequence of its density and viscidity.

I have examined this property with great care, and have been unable to discover petroleum of any description upon it; and all attempts to develop it have thus far failed.

The constant exhibition of bitumen in the form of asphaltum and maltha, upon this property, arises from the fact that the oil-bearing rocks are everywhere exposed in gentle slopes, covered with soil and gravel; or the outcrops are so near the crest of the hills that rain-water reaches them by infiltration through the plateaus and high valleys of the mountain. The immense accumulations of asphaltum are caused by the great density of the maltha, which prevents its flowing or being absorbed by the soil; and also by the absence of streams of water near the outcroppings, to bear the bituminous minerals away.

Pits, tunnels, and artesian borings have been made use of upon this property, for the purpose of developing outflows of petroleum.

Pits and open cuts were employed by Mr. Gilbert. He succeeded in increasing the flow of maltha, with but little if any improvement in regard to its quality. The quantity produced by this means, together with the natural flow of the springs, is still insignificant. Mr. Gilbert informed me that this insufficient supply of crude material was one of the chief obstacles to the success of their pioneer enterprise. Pits have only been employed by the present operators upon this property in a few localities, for the purpose of prospecting, preparatory to more extended operations.

Tunnels have been employed but a short time; in fact, have but just been commenced. The first is located in the foot-hills of the Santa Iñez Mountains, near the eastern extremity of the ranch. After passing through a soft shale for one hundred and fifty feet, a crevice was struck filled with a mass of fragments of shale cemented together with asphaltum. I am of the opinion that an additional hundred feet will be necessary to reach the rock which is the source of the maltha upon the hillside above. This great length of unproductive tunnelling, compared with that required in other localities, is caused solely by the conformation of the surface beneath the outflow. Another tunnel has just been commenced at the western extremity of the ranch, beneath an extensive outflow of maltha, which it is expected will reach the oil-bearing rocks at one hundred feet.

Artesian borings have been made upon this property at four different points. The first two locations, which are in the valley of the San Antonio Creek, were made by Mr. William H. Stone, late superintendent of the company. They were made solely in reference to the development of "a double line of artesian borings of thirteen miles." The first has been abandoned at a depth of three hundred and forty-six feet, in consequence of physical obstacles, arising from want of experience in boring in the shale formation. The second well was sunk four hundred and eighty feet, and abandoned for the same cause. A second attempt is now being made, at the same point, and is progressing favorably at a depth of about two hundred feet. Neither of these wells produced bitumen in any form, and I see no reason why they should, as they are both geologically lower than the oil shales.

A third well has just been commenced, at a point carefully selected by Mr. T. R. Bard, the present superintendent. It is located upon the "Big Spring" plateau. This location was made after a thorough examination of the exposures in the vicinity, and only with reference to striking the oil-bearing rocks, if possible, at a sufficient depth to produce unchanged petroleum. It is proposed to sink this well to a depth of 1,500 feet, if practicable. I am of the opinion that if unchanged petroleum can be obtained upon this property, this location and the depth proposed will furnish it. It is now down two hundred and sixty feet, and progressing finely. Its position in reference to the oil-bearing shales may be seen at *c* (Fig. 5, page 58).

A fourth well, worked by a spring-pole, was located by Mr. Bard in one of the cañons of the Sulphur Mountain. This well failed to produce bitumen at two hundred and eighty feet.

A fifth well, to be worked by a spring-pole, has just been located by Mr. J. B. Church, president of the company, near the eastern extremity of the ranch. I understand this location to have been made with reference to its proximity to a copious outflow of very dense maltha. It is geologically below the oil-bearing rocks.

A small refinery was commenced upon this property, but has never been completed.

The property next east of the Ojai Ranch, upon the south side of the Sulphur Mountain, is the Cañada Larga. Upon this property is a fine spring of petroleum and some half-dozen springs of maltha. The oil of this spring has a density of .930. The yield appears to be at present ten or fifteen gallons per day. I think quite an extensive outflow of dense petroleum might be developed at this point by tunnelling. I am also of the opinion that no better point for the location of an artesian boring can be found upon either side of the Sulphur Mountain than at this spring. A tunnel has been commenced in a small cañon near this spring, with encouraging indications of an outflow of petroleum if further prosecuted. No attempts have been made to develop the outflows of maltha.

In Bornträger's Cañon are tunnels, yielding, I was told, two barrels daily of good petroleum. Quite extensive outflows of maltha occur in this cañon.

Upon the Hayward Petroleum Company's property, in the next cañon east, the largest yield of petroleum upon the Pacific Coast is now being obtained. Five tunnels are in operation, from thirty to one hundred and thirteen feet in length. Their aggregate length is about three hundred feet. The flow of petroleum of all densities was recently estimated by Mr. Henry Dubbers, and I am told it amounted to twenty-eight barrels per day. Only that portion having a specific gravity of 27° Baumé and upwards is gathered; the remainder, amounting to eighteen barrels a day, is allowed to run down the creek. These heavy oils have not yet been found to be of sufficient value to warrant their transportation to San Francisco.

The light oils procured here are the finest yet obtained upon any property in this region. They are now made to yield burning oils, equal to the average of those imported from the East, and lubricating oils, considered by many to be equal to the best in the market. These results, however, have only been obtained after repeated failures and eight months of experiment, during which about one thousand barrels of crude oil were consumed. The prejudices of a market in favor of an article of long-established reputation, and jealousy of innovation, were not the least obstacles encountered. The persistent energy with which the proprietors of this estate have prosecuted their experimental labors to a successful issue is worthy of imitation by all those who have at heart the development of this interest.

Mr. Wheeler, the resident partner, has now returned to San Buenaventura, with the determination to develop, if possible, a yield of one hundred barrels per day. Judging from results already obtained, I do not consider his estimate at all exaggerated. This property is, without doubt, the most valuable of any of like extent in this region.

The refinery of this company is in San Francisco. It contains four stills. The processes employed for the manufacture of Eastern oils were found to be entirely unfitted for the manipulation of the oils of this region. Processes have, however, been discovered, after repeated experiment, which now furnish very satisfactory results.

The Stanford Oil Springs are located in the next cañon east. Mr. Samuel Moss, who has conducted operations upon this estate during the past year, has given evidence of great ingenuity in the application of limited means to the development of petroleum upon it. He has made use of shafts and tunnels, and has of the latter about five hundred feet. More unproductive tunnelling is necessary here than on the property of the Hayward Petroleum Company. The yield of good petroleum upon this property is about five barrels per day. A large quantity of heavy oil is also allowed to run to waste. The yield of good oil upon this property may be very largely increased by further development. This company's refinery is also located in San Francisco, and their experience in refining oils has been very similar to that of the Hayward Petroleum Company.

The springs of maltha in the Thompson Cañon are entirely undeveloped. Petroleum can, without doubt, be obtained here in considerable quantity by means of long tunnels.

In the Webber Cañon no attempts have yet been made to develop the springs of dense petroleum upon the mountain-side. The large outflow of maltha lower down has been developed by digging pits twenty feet in depth above the outflow. This oil, or thin maltha, was gathered and transported twenty miles, to the refinery of the Philadelphia and California Petroleum Company. I was told the pits yielded at one time eighteen barrels per week of dense oil, of a specific gravity of 23° Baumé. For the amount of labor actually expended upon this property, I consider the return greater than that obtained from any other in this section, and I see no reason why a further expenditure should not render this estate very valuable.

At the embouchure of the Sespe Cañon is an undeveloped claim belonging to Messrs. Chaffee and Gilbert of San Buenaventura. The outflow here is very light maltha. In a high valley about five miles northeast outflows of maltha occur over quite an extensive area. They are generally too low down upon the hillsides to admit of successful tunnelling, and the hills above them are too low to admit of a yield of unchanged oil. There are one or two localities where more or less oil might probably be obtained by boring. This property is, however, too difficult of access to be of considerable value.

Many outflows of maltha of varying density occur in the Circo and Piru Cañons, none of which have been developed in any manner. Some of these outflows would, no doubt, produce petroleum by tunnelling.

Opposite the Piru Cañon, in a cañon of the Simi Mountains, an extensive outflow of light maltha occurs. This is the most western outcrop upon the San Francisco Ranch, the property of the Philadelphia and California Petroleum Company. The property of this company is very extensive, but it is only upon the San Francisco Ranch that bituminous outcrops of any importance occur. The bituminous strata beneath the formation, upon the south side of the Simi Mountains, are buried beneath sandstones and conglomerates to an immense depth. This cañon presents opportunities for successful tunnelling second only to those upon the property of the Hayward Petroleum Company. The flow of light maltha has been increased somewhat by pits a few feet in depth. The other outcrops upon this estate consist of asphaltum and maltha, of varying density.

Artesian borings have been made upon this property at three different points. The first was located a short distance from the Santa Clara River, about a mile above the old Camula Ranch House. This spot was selected without any reference to outflows of any description, but in conformity to the idea that artesian borings located at random throughout this region would produce oil. Convenience, in this instance, was chiefly consulted. This well was sunk for five hundred feet, through fine argillaceous sandstone, without producing bitumen of any description. It was abandoned at this point, on account of accidental obstructions which caving rendered it impossible to remove.

Three unsuccessful attempts were next made to sink a well in one of the cañons of the Simi Mountains. This location was made by the Hon. Levi Parsons. I am told by Dr. Jonathan Letterman, late superintendent of the company, that this selection was made entirely with reference to the large amount of gas that escaped with the maltha. The greatest depth reached was one hundred and seventeen feet. All their attempts proved futile, in consequence of the density of the maltha. It was accompanied by water containing a large amount of common salt. It could neither be pumped out nor drawn out by grappling-hooks, and was so tenacious as to clasp the tools firmly, and thus prevent the possibility of further operations. Large volumes of gas are constantly escaping from the well last bored. The point selected is upon an anticlinal crest, of very loose, friable shale, about ten feet below a copious outflow of very dense maltha. The exposure is at the foot of a very gentle slope, presenting a very widely extended surface to percolation by rain-water.

In a cañon to the west of the one just mentioned, Dr. Letterman located a well, which has been bored to a depth of four hundred and eighty-seven feet. This well I consider to be most promising of satisfactory results of any in Southern California. It is situated geologically above the strata from which the maltha escapes. These strata consist of sandstones interstratified with oil-bearing shale. A calculation of the depth at which the oil-bearing strata would be pierced, based upon the dip of the sandstone where exposed, was verified within three feet. This well first passed through shales yielding very dense maltha, then through sandstone, again reaching shales yielding very light maltha. The maltha from the surface-shales was of a specific gravity of 16° Baumé. When the second stratum of shales was penetrated, a cavity was found, apparently of several feet in depth. Oil and water were driven to the surface, by the escape of gas, in sufficient quantity to overflow the artesian tubing of the well. A seed-bag and oil-pump were introduced in such a manner as to cut off the flow from the upper stratum, and the well yielded, on being pumped, a number of barrels of maltha, or dense brown oil, of a specific gravity of 23° Baumé. Mr. J. D. B. Shorb, the present superintendent, caused the well to be pumped continuously for thirty hours. During this time it yielded saline water, accompanied by light maltha in small quantities, with the exception of two intervals of three fourths of an hour each, when an uninterrupted stream of maltha was obtained.

Dr Letterman informed me that this is the most favorable location for a well that he has seen in that section, and the best upon that property. He also expressed the opinion that if a depth of one thousand feet failed to reach oil, it was of very little use to expect to obtain oil by boring. In this opinion I fully concur, and I would add that if this well were sunk to that depth, it would furnish more positive testimony relative to artesian borings in this region, than all the wells that have been sunk up to this time.

A refinery of limited capacity has been in operation, in which light malthas from the Webber Cañon, and from the cañon upon this property first mentioned, have been refined. Although the oils produced were not of the best quality, Mr. Shorb informs me that they met with a ready sale at Los Angeles and San Buenaventura, at remunerative prices. The apparatus and mode of manipulation were both such as are employed in the manufacture of Eastern oils, and are wholly unfitted for the refining of the dense products of this region. The crude material employed was inferior, and the results obtained quite as favorable as those of other parties, in their first attempt to operate upon this new product.

Crossing a low divide from the San Francisco Ranch, we enter the San Fernando Mining District. The first property east of this ranch is the Pico Spring. This spring yields the most valuable petroleum of any natural outflow yet discovered in Southern California. Only a basin has been excavated, to receive the oil as it flows from crevices in the rock. Seventeen hundred and fifty gallons had been sent away from April 9 to June 18, and a considerable quantity, say one hundred gallons, remained on hand. This would give an average yield of from twenty to twenty-five gallons per day. I consider this to be the most favorable locality for an artesian boring in Southern California. The anticlinal crest of the oil-bearing shales is here exposed in a steep cañon, the crest being overlaid with unbroken bands of sandstone and conglomerate, which effectually prevent rain-water from reaching the bituminous strata. The oil yielded here at the surface is from 26° to 28° Baumé.

Next east of the Pico Spring is the Hewes Claim, upon which a spring-pole well is located, from eight hundred to one thousand feet above the Pico Spring. More perseverance, industry, and energy, than sound judgment, are evinced in the selection of this point for boring. The well is one hundred and sixty-five feet in depth. Operations are suspended at present on account of a drill-bit that is stuck fast at the bottom. Petroleum rises in this well for forty feet, and one or two barrels have been taken out of a specific gravity of 26° Baumé. The indications of bituminous strata upon this property are not easily accessible, but I consider that they offer far greater inducements for development by tunnelling than by boring. The oil-bearing rocks may be penetrated by a tunnel two hundred feet in length far below the point now reached by boring. I was told that the proprietors intended to sink this well with a spring-pole to a depth of one thousand feet; a project which the experience of many has proved to be utterly impracticable. The anticlinal crest of sandstone and conglomerates is here broken through so as to expose the crest of the shale for a few yards in width. The well is located upon this anticlinal.

The Moore Claim next east embraces two cañons opening into the Pico Cañon. In the west cañon a very extensive outflow of light maltha occurs. The anticlinal of solid rock is here broken through for about one hundred yards in width, leaving the shale exposed in quite steep declivities. A horizontal tunnel thirty feet in length yielded an increased flow of light maltha. I think deep boring would yield at this point oil of better quality, though perhaps not in so large quantity as tunnels. In the east cañon of this claim, three wells have been put down, with a very imperfect spring-pole apparatus, to a depth of fifty, fifty, and forty-five feet. Two of them, I was told, reached petroleum, probably very dense. I consider this claim capable of yielding a large amount of material by proper methods of development.

East of the Moore Claim is the Tousley Spring, in a cañon nearly parallel with the Pico Cañon. Mr. Rushmore, who superintends the work now going on there, informed me that the well upon this property was yielding three and one half barrels per day of very light maltha. This well is one hundred and sixty-six feet in depth. The quality of the maltha has improved from a very viscid maltha of a specific gravity of 16° Baumé, to a light maltha of a specific gravity of 20° Baumé. There is also a tunnel upon this property forty feet in length; the yield is a very dense maltha which is not gathered.

In the next cañon east are the Wylie Springs. A well upon this property has been sunk to a depth of one hundred and seventy-seven feet. It passed through sandstone interstratified with thin layers of shale, and yields a very small quantity of petroleum of a density of 28° Baumé. There is also upon this property a tunnel, one hundred and eighty feet in length, yielding one and one half barrels per diem of petroleum of a density of 20° to 22° Baumé. At the time of my visit (June 18) this tunnel was being pushed forward, and three others were just commenced. The Wylie Springs and Tousley Claim are being operated by the same parties, under the title of the Wylie Springs Oil Company. Operations were commenced last August, since which time the property has produced two hundred and sixty barrels of petroleum and light maltha.

East of the Wylie Springs is the Rice Claim, upon which is an outcrop of maltha. A well has been sunk upon this property to a depth of sixty feet, and is now idle in consequence of a bit having been lost in it.

The labor that has been expended upon these properties amounts to little more than prospective operations. The great distance from shipping points, from fifty to sixty miles, and the density of the oils thus far produced, have been great obstacles to overcome in the development of this region. The desire universally expressed by those engaged in the development of these properties is that a refinery should be located in the immediate neighborhood of the springs. A refinery located at the head-waters of the Santa Clara River would prove a valuable enterprise in itself, and at the same time furnish the greatest stimulus to the development of this entire section. I consider that this section, properly developed, is capable of furnishing an amount of oil nearly equal to that of the San Buenaventura District, and of superior quality.

From the San Fernando Pass to the Cañada de Brea, twenty-five miles from Los Angeles, various outcrops of asphaltum and maltha occur in the low foot-hills of the San Gabriel Mountains; running along the northern boundary of the San Fernando plain, and north of Los Angeles and Anaheim. I have been unable to learn that any outflows between these two points have been developed in any manner.

At the embouchure of the Cañada de Brea the Santa Ana Oil Company have sunk a well to a depth of three hundred feet. At the time I visited this property (June 16) work upon the well had been suspended. The location for this well was selected by Major Strobell. It is geologically below the oil-bearing belt of strata. The exposures in this vicinity are numerous, and furnish unmistakable evidence of the superposition of the strata. An artesian boring located one thousand yards from the present well, in the direction of Anaheim, could not have failed to pierce the bituminous shales. The fact that the present well has yielded very small quantities of light maltha leads to the supposition that a well properly located might have yielded more or less of a similar or more valuable substance. Mr. Darling, who has been superintending the work since last December, informed me that at the time he took charge, the well was one hundred and fifteen feet in depth, and that the strata pierced since that time had been sandstones and conglomerates interstratified with very thin bands of argillaceous rocks. Light maltha had appeared at different points in very small quantities, apparently an infiltration through crevices. I consider that this locality is very favorable for the location of a well, with a reasonable expectation of obtaining bitumen, either as petroleum or light maltha.

Southwest of the town of Los Angeles an undulating plain extends for several miles towards Wilmington and the Cahuenga Pass. Very extensive outcrops of maltha and asphaltum occur at various points upon this plain and among the low hills west of the town. Asphaltum, for the purpose of covering the roofs of houses, has been obtained from these deposits from immemorial date. An attempt to manufacture merchantable oils by the distillation of the asphaltum, was made some years since by Mr. Gilbert of San Buenaventura. I am told the attempt proved a pecuniary failure.

Two attempts to obtain oil by boring have been made by the Los Angeles Pioneer Oil Company upon these outcrops. They have been thus far unsuccessful. The first well was located about two miles south of a point equidistant from Los Angeles and the Cahuenga Pass. This well was abandoned at a depth of four hundred and sixty feet. Maltha was struck at this point. The boring passed through sandstones interstratified with shale.

The second attempt was made at a point about four miles northeast of the first location. I think this location was made by Mr. Polhemus, who superintends the work upon the well. At the time of my visit (June 16) work had been suspended for some time, but it was to be resumed upon the following Monday (the 18th). The depth of this well was at that time three hundred and seventy feet. It passed through sandstone one hundred and forty-five feet, then through ten feet of shale, thence through sandstone one hundred and fifty-five feet, again passing through ten feet of shale, below which sandstone continued for the remaining fifty feet. Immense quantities of water constantly flow from this well. The quantity has been estimated by some as high as fifteen hundred barrels per day. The water is accompanied by maltha in quantity scarcely amounting to more than a trace. The water issues from between the sandstones and shales, the maltha from between the strata of shale.

The rocks upon this plain and among these hills, whenever exposed, stand at a high angle with a southerly dip. They are susceptible of percolation by rainwater to an immense depth. The second well is located geologically above the outflow; but I consider it very doubtful if it is practically possible to penetrate strata so exposed to a sufficient depth to obtain unchanged petroleum.

Mr. Polhemus has a small refinery near his second well. His first attempt at distillation accidentally caused the destruction, by fire, of his engine and most of his apparatus. Nothing daunted, he again placed his still and apparatus in order, and at the date of my last visit (June 16), he had made sixteen barrels of burning oil, pronounced by those who had tested it to be of very good quality. He used the oil of the Pico Spring, and sixty barrels of very dense maltha, from the well upon the Tousley Claim.

Parties recently engaged in sinking a shaft, preparatory to boring, upon the plain before mentioned struck a deposit of sand and gravel saturated with bitumen, at about thirty feet below the surface. The shaft has been sunk fifteen feet upon the stratum, which appears to extend much deeper. The saturated sand appears to the eye to be precisely the same in character as the deposit found at Rincon Point, formerly worked by Dr. Morrill. Experimental operations conducted by Messrs. Sevenoakes and Swift, the parties who discovered the deposit, furnished results entirely different from those which I am informed were obtained by Dr. Morrill. Mr. Swift informed me that the bituminous sand yielded, upon being retorted, thirty gallons per ton of an oil of a specific gravity of .850, or 35° Baumé. He also showed me a certificate of a chemist of San Francisco, stating that the crude oil yielded, upon redistillation after treatment with chemicals, ninety per cent of burning oil of a specific gravity of .840, or 38° Baumé. An oil of 38° Baumé is too dense to burn well; but this crude oil will no doubt yield seventy-five per cent of an oil of specific gravity 41° Baumé, and thereby prove very valuable. The retort used by these gentlemen was a very imperfect one. I was of the opinion that this oil was the lighter portion of the distillate reserved for distillation and rectification, until positively informed by Mr. Swift that such was not the case. I am unable to learn that any other bituminous product of Southern California furnishes upon distillation corresponding results. These gentlemen intend to erect a retorting establishment, for the purpose of obtaining oil from this substance upon the large scale.

I am told that a well is being sunk near San Diego, but I have been unable to learn any particulars concerning it.

Upon a careful perusal of the foregoing pages, I think it will be readily conceded that Southern California has veritable oil-interests. That these interests are still in their infancy is equally obvious. Like all enterprises, that are of a new and in part experimental character, they have involved much unproductive and apparently useless expenditure. Such expenditure, however, is now no longer necessary. Methods of development, which have proved productive in one or more localities, need only judicious application to other similar exposures to produce corresponding or approximative results.

There are very few localities where it appears possible that oil may be obtained in remunerative quantities by boring. None of those which appear to be most favorable are at present being developed by this method. Rash and indiscriminate locations of artesian borings, upon the basis of false reports and erroneous comparison, have occasioned the useless expenditure of large amounts of capital; and through their failure to furnish correspondingly exaggerated results, the entire oil-interest has been depressed far below its real value. I consider that capital should be very sparingly applied to the development of this interest by artesian borings.

Tunnelling is at present furnishing the only satisfactory and pecuniarily successful method of operation. It has the advantage over boring, that it admits of application, with a very fair estimate of the return that it is capable of yielding. It does not therefore necessitate so great risks. It must not, however, be supposed that every declivity in Southern California upon which a bituminous outcrop occurs is capable of yielding a return upon capital invested in this manner. On the contrary, the number is quite limited; yet these are destined, I think, when properly developed, to yield a continuous flow for a long period. The cost of operating by this method is, upon the average, not more expensive than boring; and when once in operation, they require much less attention than any pumping-wells. The flow from the tunnels of the Hayward Petroleum Company has continued, for more than six months, to furnish an undiminished supply of oil of unimpaired quality, with only the expense of barrelling. . Running in 1896.

The San Buenaventura District is at present yielding almost the entire product shipped, but there is no reason why other localities should not contribute their supply, so that eventually the market of San Francisco will look to that source alone for both illuminating and lubricating oils. It is not a year since work was first commenced, yet there has been shipped from San Buenaventura nearly 2,500 barrels of crude oil.

The following exhibit, for which I am indebted to Mr. Henry Dubbers of San Buenaventura, will show the amount shipped by different parties prior to June 25, 1866: —

Petroleum Shipments made at San Buenaventura.

1865.			**Bbls.**
Aug. 11.	Brig Curlew,	Stanford Bros.	10
Sept. 4.	Schooner Roscoe,	"	14
"	"	Piejol (Hayward Petroleum Company)	30
18.	Brig Merchantman,	Stanford Bros.	32
Oct. 8.	Steamer Senator,	Hayward Petroleum Company. .	104
11.	Schooner Lewis Perry,	" " " .	100
17.	Brig Curlew,	Stanford Bros.	27
Nov. 28.	Brig Merchantman,	"	42
"	"	Hayward Petroleum Company. .	349
"	"	Beardsley	24
"	"	Bornträger	15
Dec. 10.	Schooner Lewis Perry,	Hayward Petroleum Company .	13
1866.			
Jan. 2.	Brig Curlew,	" " " . .	10
29.	Brig Merchantman,	" " " .	105
30.	"	" " " . .	10
Feb. 20.	Schooner William Ireland,	" " " .	354
"	" "	Stanford Bros.	265
"	Schooner Lewis Perry,	"	49
Apr. 6.	Brig Merchantman,	Hayward Petroleum Company .	150
"	"	Stanford Bros.	120
"	"	Bornträger	10

1866.			Bbls.
Apr. 16.	Schooner Lewis Perry,	Hayward Petroleum Company	80
"	" "	Stanford Bros.	171
May 8.	Brig Curlew,	Hayward Petroleum Company	94
June 22.	Schooner Lewis Perry,	" " "	161
"	" "	Stanford Bros.	109

Total.

Stanford Bros. (Stanford Oil Springs)	839
Hayward Petroleum Company	1,560
Beardsley (Cañada Larga)	24
Bornträger	25
Total shipped	2,448

Besides this amount shipped, the Webber Cañon has yielded, I should think, at least one hundred barrels of light maltha, and the cañon upon the property of the Philadelphia and California Petroleum Company as much more. The Pico Spring, in the San Fernando Mining District, has yielded one hundred and fifty barrels of very fine petroleum; and the Wylie Springs Oil Company had shipped and on hand two hundred and sixty barrels of light maltha and petroleum. There are also about twenty barrels of heavy petroleum at the Cañada Larga Spring. This gives a total gathered yield of 3,078 barrels for the first ten months during which labor of any description has been expended upon any of the properties.

In addition to this amount, at least twenty-five barrels per day are allowed to run to waste upon the properties of the Hayward Petroleum Company and the Stanford Oil Springs. This product has heretofore been considered of too little value to warrant the expense of transportation to San Francisco; but I am told that preparations are being made to gather the larger portion of these dense oils, say twenty barrels daily. None of the dense malthas from the Webber Cañon or the cañon upon the San Francisco Ranch have been gathered for the last five months. The two localities will yield together at least twenty-five barrels per week. This would give a total yield for the first ten months, in round numbers, of 7,000 barrels.

The daily yield now being preserved is: —

	Bbls.
Hayward Petroleum Company	10
Stanford Oil Springs	5
Bornträger	2
Pico Spring	.5
Wylie Oil Springs Company	5
Total	22.5

This is equal to a total yield per month of 675 barrels. Only three and one half barrels per day of this amount is yielded by artesian borings, and that is the most inferior in quality of any that is preserved.

If the development of the property of the Hayward Petroleum Company is pushed forward during the next six months, I know of no reason why that estate alone should not yield an amount of oil double that now produced throughout the entire region, and I consider that other properties admit of development in like proportion.

The expectation of extraordinary results, that will admit of comparison with those that have been produced in Pennsylvania, must be set aside without the shadow of a hope to rest upon. The expectation of a fair return and a permanently profitable investment may be reasonably entertained; and the application of capital upon this basis to the development of this interest will make it of great importance to the State, and of unequalled importance to that particular section in which the bituminous outcrops occur.

PART II. CHEMICAL INVESTIGATIONS.

(SECTION I. FEBRUARY, 1867.)

NOTE. I take this opportunity of returning my thanks to Professor C. M. Warren of Brookline, Mass., for the assistance he has rendered me by the use of his laboratory and apparatus; also to Professor J. H. Appleton of Brown University, and "The Providence Franklin Society," for similar favors.
S. F. P.

BEFORE leaving Southern California, in accordance with instructions of the State Geologist communicated to me in April last, I procured such samples of the various bituminous products of that region as I thought would, when subjected to experiment and analysis, furnish such information respecting their value, when compared with each other and Pennsylvania petroleum, as would be of worth to the citizens of California. These samples consisted of three varieties of petroleum, two of maltha, and two of asphaltum. I shall number them from one to seven.

No. I. is a petroleum from the first tunnel run by the Hayward Petroleum Company, in their eastern or "Brea" Cañon. It was dipped by myself from a tank containing at the time, I should think, one hundred barrels of oil. The oil in the tank was in color of a light sap-green, and was the lightest colored petroleum that I have ever seen. It came from a tunnel fifty feet in length, which penetrated a bed of asphalt and débris for several feet before entering the solid rock.

Tunnel was running oil in 1892

No. II. was taken from a pool in the Pico Cañon, generally known as the Pico Spring, a few miles west of the San Fernando Pass. The oil issues from crevices in the perpendicular face of a bluff above the pool. When gathered, it was of about the color of good Pennsylvania petroleum, which is of a darker green than No. I., when freshly gathered.

No. III. was taken from the small pools at the Cañada Larga Spring. The oil reaches the surface, accompanied by many times its volume of water, impregnated with hydrosulphuric-acid gas. The water comes to the surface highly charged with sulphur, a portion of which becomes free upon contact with the atmosphere and is dissolved by the oil. This oil, when gathered, was intermediate in color between Nos. I. and II. All of these oils, when opened in Boston, about ten weeks after they were gathered, resembled each other so nearly in color that scarcely any green tint could be discerned in either of them.

No. IV. was taken from the outcrop of maltha upon the right of the road, just beyond where it enters the Ojai Ranch from the San Buenaventura Valley. The maltha was accompanied by about an equal volume of sulphurous water. It is a very fine, clean sample, of about the average density known in that region as "tar."

No. V. is a more dense variety of maltha, heavier than water, taken from a tank upon the Ojai Ranch near Gilbert's old works, the one described by Dr. C. T. Jackson as containing "petroleum." This is a very dense specimen, almost as heavy as asphaltum, and of about the consistence of soft mortar. It is also accompanied in its flow by sulphurous water.

No. VI. is also from the Ojai Ranch, and of about an average degree of purity.

No. VII. is a variety of asphaltum from a bed near the "Big Spring" on the Ojai, of more than average purity.

It will be observed that these samples form a series, arranged according to their density, beginning with the least changed petroleum obtained from the extremity of the tunnel, and ending with solid asphaltum. I also examined specimens of asphaltum, from the large vein at La Goleta, from a bed upon the hillside east of the town of Santa Barbara, and a fragment, which had been melted, from a bed upon the Ojai Ranch. The latter is the purest specimen of asphaltum that I saw while in California, resembling albertite more than any of its congeners.

Two subjects for investigation presented themselves to my mind as of paramount importance in regard to the industrial value of these oils, etc. The first was the discovery or application of some principle or process not yet introduced into the manufacture of these crude materials, that would add either to the quantity or quality of commercial products manufactured from them. The second was the study of their elementary constitution, embracing not only the ultimate but proximate analysis of the crude and manufactured oils.

I became convinced, before leaving the Pacific Coast, that the condition of the refining business could not remain as it then was, should the yield of crude material be increased to such an extent as to promise a steady supply sufficient for the San Francisco market. The proportional yield of illuminating and lubricating oils, without regard to quality of either, was evidently such as to render lubricating oil a drug in the market long before the demand for burning oil had been supplied. This being the case, the only hope for the oil-interest was either the production of lighter crude oil, or the production of oils of a grade equal to the best then produced in much greater quantities at a less cost, so that the lubricating oils might not continue to be essential to profitable manufacture. The occurrence of either event appeared of remote probability. I make this statement the more boldly because the most favorable estimate of the consumption of petroleum lubricating oils should still leave a very liberal margin for the sale of both lard and sperm oils at much higher rates. Such is the case in the Eastern market, where very superior paraffine lubricating oils have long been introduced, and where rigid economy is one of the first requisites of successful manufacturing. Yet there are those there, as in San Francisco, who prefer mineral lubricating oils to any others excepting the best sperm oil. To increase the yield of illuminating oil in proportion to that of lubricating oil, I deemed to be of first importance.

The principle upon which the formation of gas depends when made from tar or petroleum was long since successfully applied by Mr. Merrill, of the Downer Kerosene Oil Company of Boston, to the manufacture of illuminating oil from heavy paraffine lubricating oils, and even from solid paraffine wax. The principle is this, that by heating hydrocarbons to a temperature above their boiling-point (the degree depending upon that point), they are resolved into hydrocarbons of less density and lower boiling-point, with deposition of carbon as coke. At or near a red heat, a permanent gas is formed; at a lower degree of heat, intermediate between the boiling-point of mercury and a red heat, light oils are formed similar in physical properties to those produced by natural causes in crude petroleum. The process patented by Mr. Merrill is named by him "cracking." It is conducted in an upright still, having a high dome, which is constantly maintained by conduction and radiation at a temperature below that of the boiling oil beneath it. The goose-neck leading to the worm is so adapted to the dome as to prevent any of the vapors condensed upon it from flowing into the worm. As a consequence, the heavy vapors of oil boiling at a high temperature are condensed upon the dome, and fall back, drop by drop, upon the surface of the oil beneath, which has, meantime, become heated above the boiling-point of that which is falling. By conducting the distillation with sufficient slowness to insure the complete condensation of all the heavy vapors as they ascend, only the light oils distil over; and in time the crude material becomes resolved into gas, light oil, and coke. This process is necessarily very slow and tedious; but at the same time, where fuel is not an important item, it is inexpensive and very effectual.

While revolving in my mind various schemes for accomplishing the same thing, I noticed in the "Chemical News" the report that a patent had been issued in England to a man in New Brunswick, for a process by which paraffine and other heavy oils were distilled under pressure for the purpose of obtaining light illuminating oils. The specification simply stated that the distillation was conducted in a plain cylinder boiler, tested to a pressure of one hundred pounds per square inch, the pressure to be regulated by ordinary valves and gauges. The latter statement I do not believe admits practically of literal application. The leakage of an ordinary safety-valve when raised by a pressure of from twenty to forty pounds is immense, while the elasticity of the brass springs of an ordinary steam-gauge I believe to be so seriously impaired at the temperature at which those oils distil as to cause them to cease to be reliable as registers of pressure. In place of these, an ordinary steam-chest should communicate with the boiler by a small orifice, into which a valve is carefully ground. The valve should have a spindle passing through guides above and below its seat, to insure that it will always fall squarely. A weight should be placed upon the upper spindle, in amount proportioned to the pressure required, which should be greater or less in proportion to the density of the crude material. This weight, together with the flow from the worm, and well-regulated fi~~t~~s should be sufficient to insure a uniform pressure and flow. An ordinary safety-valve, carefully ground, and loaded to one hundred pounds, would perhaps be an additional safeguard against accident from clogging of the condensing apparatus. The escape-pipe from this valve should lead well up above the still, as the very hot vapors of these oils sometimes take fire when projected into the air.

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For all the varieties of petroleum represented by Nos. I., II., and III., this process has furnished results of a very highly gratifying character. My experiments were conducted in a small iron retort, to which was attached a valve operating precisely in the same manner as that just described. The small size of the valve rendered it impracticable to use weights; the pressure was therefore regulated by a spiral spring, which was adjusted by an Ashcroft's steam-gauge. The amount of pressure made use of was about thirty pounds per square inch.

1,500 c. c. of No. 1. yielded 1,365 c. c. of crude distillate, which yielded by redistillation in a glass retort, with proper fractionation, 630 c. c. of a sp. gr. 43° Baumé, = .810. This is a yield of 91 per cent of crude distillate, and of 42 per cent of burning oil. The residue from the crude oil consisted of coke and loss. The residue from the pressure distillate consisted of heavy oil, which, by redistillation under pressure and a second fractionation, yielded of burning oil about 12.5 per cent of the original crude material. The residue from the second fractionation consisted of a considerable amount of heavy oil, amounting to about 25 or 30 per cent of the original crude oil. This oil, when heated, as it ran out of the retort, proved to be as fine lubricating oil of sp. gr. 23° – 25° Baumé, as I have seen produced pure from California petroleums. This gives, as the result of two distillations under pressure and two fractionations, 54 per cent of illuminating oil, and 25 to 30 per cent of lubricating oil. This lubricating oil may by repeated distillations be resolved into illuminating oil and coke; but with the same pressure the amount of oil broken up, or "cracked," is less for each successive distillation. For this reason I am led to believe that there may be a limit to the *profitable* redistillation of the heavy residue, especially as that from the second fractionation can be run off from the retort without passing through the worm, and be treated immediately, producing a lubricating oil of very fine appearance.

Both the crude illuminating and lubricating oils lose about three per cent of their volume by treatment with sulphuric acid and soda lye.

As the three oils, Nos. I., II., and III., when subjected to the same treatment, furnish results differing only in the quantities of the respective products, I shall present those results in a tabulated form. 1,500 c. c. of the crude material were operated upon at one time.

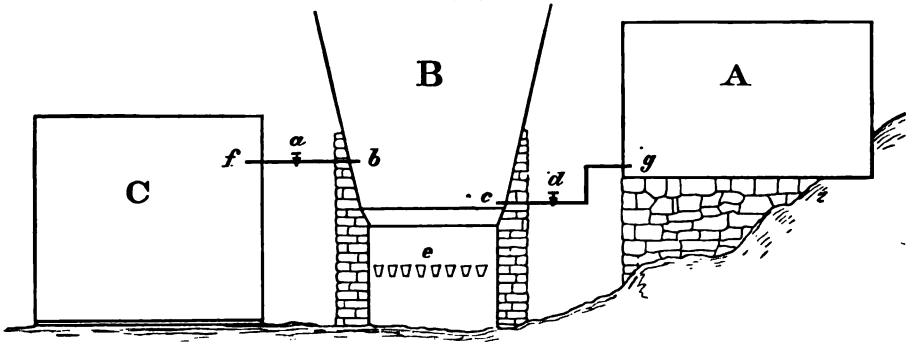
		1st Pressure Distillation.	Coke and Loss at do.	1st Fractionation of Sp. Gr. 43° B.	Heavy Residue for Redistillation.	Yielding by 2d Pressure Distillation.	2d Fractionation of Sp. Gr. 43° B.	Total crude Illuminating Oil.	3% Loss in treating Illuminating Oil.	Total Yield of Refined Oil.	Total crude Lubricating Oil.	3% Loss in Treatment of do.	Total refined Lubricating Oil.	Yield of Refined Illuminating Oil.	Yield of Refined Lubricating Oil.	Loss in Refining.	Loss in Distillation.
Cubic Centimetres.	I.	1365	135	630.0	735.0	681.00	184.00	814.00	24.42	789.58	497.00	14.91	482.09	789.58	482.09	39.33	189.00
	II.	1315	185	850.8	464.2	408.78	102.19	952.99	28.59	924.40	306.59	9.19	297.40	924.40	297.40	37.78	240.42
	III.	1240	260	605.0	635.0	571.50	142.87	747.87	22.43	725.44	428.63	12.85	415.78	725.44	415.78	35.28	323.50
Percentage.	I.	91.00	9.00	42.00	49.00	45.40	12.27	54.27	1.63	52.64	33.13	.99	32.14	52.64	32.14	2.62	12.60
	II.	87.66	12.34	56.72	30.94	27.25	6.81	63.53	1.91	61.62	20.44	.61	19.83	61.62	19.83	2.52	16.03
	III.	82.66	17.34	40.33	42.33	38.10	9.52	49.85	1.49	48.36	28.58	.86	27.72	48.36	27.72	2.35	21.57

The loss in distillation in Nos. II. and III. is greater than in No. I.; this is due in part to the fact that I commenced my experiments with No. III., and had acquired some skill in the use of my apparatus before testing No. I.

Of the two specimens of maltha I have confined my investigations to No. IV. This specimen is a fair average of the malthas found throughout that region. It is the lightest, with but one exception, of any found upon the Ojai Ranch in any natural outcrop; and the springs in the Webber Cañon, those of Messrs. Chaffee and Gilbert in the Sespe Cañon, and those in the Torrey Cañon at the western extremity of the San Francisco Ranch, are the only other localities yielding true malthas of superior quality.

The first obstacle encountered in its distillation is the large quantity of air, hydrosulphuric-acid gas, and water mechanically mingled with it. The viscidity of the substance, and the amount that invariably adheres to all vessels used in measuring it, render it exceedingly difficult to estimate accurately the amount of these impurities. An estimate made in California upon a considerable quantity of the product of the same spring gave the amount of loss from this cause as twelve and one half per cent. These impurities cause the substance, when heated even at a very low temperature, to foam so much that, when uncontrolled, it will increase the bulk under 200° Fahr. to twenty times its original volume, causing it to fill still, condenser, and receiver before an atom has passed into vapor. I have succeeded in avoiding this obstacle by a very simple and inexpensive arrangement of three tanks, one of which may be heated by direct heat, the waste heat of a flue, or superheated steam. The temperature required is at or near 230° Fahr. The arrangement is as shown in the annexed figure.

FIG. 6.



Let *A* be a wrought-iron tank, the receiver for crude maltha; *B* a wrought-iron tank set in brick or stone work, and *C* a wrought-iron tank for receiving the heated oil or maltha; *e* is a fire grate, or the main flue leading to the stack, as is most convenient, or *B* may be seated on solid stone-work, and may be heated by a coil through which passes superheated steam. Wrought-iron pipes *f b* and *c g* connect the three tanks together. A strainer should be placed over the pipe at *g*. The pipe enters *B* as near the bottom as possible at *c*, and passes out at *b* about twelve inches from the bottom; *a* and *d* are cocks for regulating the flow. *B* is moderately heated, the cock *d* is opened and the maltha permitted to flow into it. By the time it commences to flow off at *b* it should be heated sufficiently to expel all the volatile impurities. The capacity of *B* should be from eight to ten times its capacity below the point *b*. The maltha should enter *B* from *A* only with sufficient rapidity to be properly heated, and it should flow off at *b* as rapidly as it enters from *A*. The completion of the process may be determined by heating some of the maltha as it flows from *f*; it should boil without frothing. The diameters of the pipes *f b* and *c g* should be to each other as one to two, on account of the difference in density of the hot and cold maltha. If desired, when treating the lighter varieties of maltha, the top of *B* may be covered, and a goose-neck be made to connect with a condensing apparatus. I have not observed, however, that an appreciable amount of vapor is given off during this process, when it is properly conducted and the lowest possible degree of heat made use of. The operation should not be conducted with too great rapidity.

The products of the treatment of this specimen by distillation under pressure, after first expelling the air, water, etc., are shown in the table below. Fifteen hundred cubic centimetres of the crude material were used.

	Cubic Centimetres.	Per cent.
Volatile impurities	187.50	12.5
1st pressure distillate	1080.00	72.0
Coke and loss at do.	232.50	15.5
1st fractionation of 43° Baumé	250.00	16.7
Heavy residue for redistillation	830.00	55.3
Yielding by 2d pressure distillation	747.00	49.8
2d fractionation of 43° Baumé	186.75	12.4
Total crude illuminating oil	436.75	29.1
3% loss in treating illuminating oil	13.10	.9
Total yield of refined illuminating oil	423.65	28.2
Total crude lubricating oil	560.25	37.4
3% loss in treating lubricating oil	16.80	1.1
Total refined lubricating oil	543.45	36.3
Yield of refined illuminating oil	423.65	28.2
Yield of refined lubricating oil	543.45	36.3
Loss in refinery lubricating oil	29.90	2.0
Loss in distillation, etc.	503.00	33.5

These malthas furnish a considerable amount of coke, and for this reason it would probably be better that they should be retorted before distillation, and also because of the difficulty of making a boiler tight under pressure, from which the coke may be readily extracted. The retorts used by Mr. Gilbert of San Buenaventura were D-shaped and of wrought-iron, open at both ends. He told me that they worked well, and I see no reason why they should not. They were of about three times the capacity of common gas-retorts.

I believe that all the localities producing maltha in sufficiently large quantities to make it an object to gather it, may be made more or less profitable as sources of crude material for the manufacture of lubricating and illuminating oils by this process.

I had too little of each of the crude asphalts to warrant an attempt at their distillation. Five pounds each of Nos. VI. and VII. gave twenty and seventeen per cent of impurity insoluble in benzole. The impurity consisted of bits of shale, soil, grass, sticks, and leaves. Both these specimens appear to be very nearly pure.

While in California, I subjected one hundred pounds of each of these varieties to distillation, in an apparatus which admitted of a large percentage of loss by leakage, with the following results:—

	No. VI.	No. VII.
Crude oil . . .	14.2500 pts., sp. gr. .905	6.875 pts., sp. gr. .910
Water	11.0965 "	10.340 "
Coke	50.0000 lbs.	57.000 lbs.
Loss	24.5000 "	25.000 "

This gives for No. VI. 35.625, and for No. VII. 17.1875 gallons per ton of 2,000 pounds, of an average specific gravity .906, or an average yield of 26.4062 gallons per ton. No. VII., though the purest asphalt, yielded the least oil, because it was an older, more compact, and perfectly changed asphalt than No. VI. Hence also the larger yield of coke. These distilled oils were of intolerable odor, and the most impure of any similar product that I have ever seen. The water was very strongly ammoniacal. The coke was compact, and in burning produced a very intense heat. The loss consisted of leakage, hydrosulphuric-acid gas, and empyreumatic vapors; the latter the result of the decomposition of non-bituminous organic matters contained in the asphalt.

Besides these specimens I estimated the amount of impurity in a sample from the large vein at La Goleta. This is the purest in appearance of any deposit of asphaltum in that region. It is perfectly homogeneous in its consistence, has an irregular, almost splintery fracture, and is clean and dry to the touch. It fused over a water-bath, and lost nine tenths of one per cent of its weight after digestion for two hours. Forty-five and twenty-two one-hundredths per cent was insoluble in bisulphide of carbon, of which forty-four and eighty-nine one-hundredths remained unburned at a red heat. This incombustible residue consisted of very fine slate-colored sand, evidently pulverized shale.

Another sample from the hills east of Santa Barbara, when treated in precisely the same manner, yielded results, of which the following table exhibits a comparison with those given above:—

	La Goleta. Fusible at 212° F.	Santa Barbara. Infusible at 212° F.
Loss by 10 hours' digestion at 212° F.,	.90 per cent.	.80 per cent.
Soluble in bisulphide of carbon,	53.88 "	9.09 "
Residue combustible at a red heat,	.33 "	.70 "
Residue incombustible at a red heat,	44.89 "	89.41 (quartz sand).
	100.00 "	100.00 per cent.

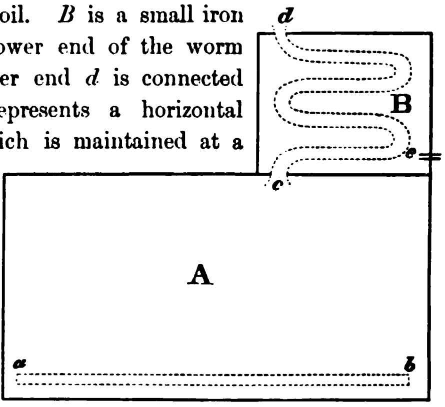
The last specimen has more the appearance of sandy asphaltum than of asphaltic sand.

Another specimen found upon the Ojai Ranch, of which perhaps five or ten pounds might have been collected, had been fused by the burning of the superimposed mass. It contained only a trace of impurity.

It will thus be seen that the asphalts contain from seventeen to ninety per cent of impurity. If the former amount of impurity consisted of clean sand, it would not have prevented the asphaltum from yielding a considerable amount of valuable distillate, and this, in connection with the fifty-seven per cent of coke, might possibly have, in the most highly favored localities, left a margin of profit; but as the impurity consists in large proportion of woody fibre, the distillate becomes contaminated with the coal-tar and wood-tar products. Such a mixture can only be purified at comparatively very great expense. For the reason that Nos. VI. and VII. are quite as pure as what would be called "good asphalt" throughout the country, I am led to believe that its manufacture cannot be made profitable at present. The low melting-point of the asphaltum causes it to run together into a solid mass before it will either burn or distil. This renders it impossible to reduce it to coke excepting in retorts or closed vessels of some kind.

By distillation under pressure, a small amount of very light oil is formed, which corresponds in some respects to the naphtha of Pennsylvania petroleum. Nothing of this kind, however, is found in the crude California oils. The amount is so insignificant that I have not estimated it in the above table, as it would more than be counterbalanced by the increased loss by leakage from small apparatus. The quantity is still sufficient, if it is not removed, to render the burning-oil subject to too low an explosive test for safety. To avoid the formation of these explosive oils, the distillation under pressure should be conducted with great care, and the pressure and rapidity of distillation so regulated as to insure the largest production of oils of medium density, together with the smallest amount of coke and light explosive oils. The skill requisite for this purpose can only be acquired by experience upon the large scale. These light vapors, when formed, may be removed most economically by means of an apparatus patented by C. M. Warren, Esq., of Brookline, Massachusetts. The following section (Fig. 7) will illustrate the method of operation.

FIG. 7.



A is a covered iron tank of any dimensions, being the general receptacle of crude illuminating oil. *B* is a small iron tank in which is a worm *c d*. The lower end of the worm communicates with the tank *A*, its upper end *d* is connected with a condensing apparatus; *a b* represents a horizontal steam-coil. *B* is filled with water, which is maintained at a temperature of 110° Fahr. by means of the steam jet *e*.* *A* is filled with crude distillate, and is heated by the coil *a b* to from 150° to 175° Fahr. All the oils passing into vapor at or below that temperature distil over, and pass into the worm *c d*; when all remaining in a state of vapor at 110°

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* I am not sure that in the warm climate of Southern California any steam jet would be necessary, but water warmed in the sun might be run through the tank *B*. Possibly exposure of the crude distillate in shallow tanks to the sun's rays might effect the removal of the light oils without the aid of heat from an artificial source.

Fahr. pass into the condenser, while the residue are condensed and fall back into the tank *A*. When light oil ceases to run from the condensing apparatus, the operation is finished.

This process is simple and inexpensive, and insures absolute uniformity in the point at which the refined oil gives off explosive vapors, and also the smallest possible amount of loss from light oil.

When the quantity of light oil is very small, but still sufficient to render the burning oil explosive, it may be expelled by injecting steam into the soda tank during agitation, and heating the oil to 115° or 120° Fahr.

The results given in the above table, like all others obtained by operations conducted with small apparatus, exhibit a larger percentage of loss in distillation than would be found when conducting similar operations on the large scale. This is in consequence of the proportionally larger size of all the openings in the apparatus, which require luting. It is impossible to render such joints tight at the high temperature at which the heavy oils distil, or under a pressure of thirty or forty pounds. Results obtained on the small scale should be considered more as guides to point the way by which more extensive operations should be conducted, than as exhaustive evidence for or against any question attempted to be solved by them. I have found in my own experience that large operations furnished better results than small, when the crude material was Pennsylvania petroleum, and I see no reason why by this method a larger yield of finer quality should not be the product of the distillation of these oils in large quantity under pressure.

A comparison of the results of the distillation of the malthas and oils appears at first sight to give the latter great preponderance in value over the former. But it should be borne in mind that the malthas contain twelve and one half per cent of volatile impurity not contained in the oils. After making due allowance for this fact, it will be observed that the total amount of crude distillate is in all cases very nearly in the same proportion to the pure bitumen contained in the crude materials.

These crude distillates yield easily to treatment with the ordinary amount of sulphuric acid and soda lye. The purified oil is very transparent, and the most free from color of any that I have ever seen. Indeed, were it not for its opalescent properties, and the peculiar manner in which light is refracted by it, this oil could not be detected in its appearance from pure water.

I do not claim to have produced oils, the burning qualities of which are superior to other California oils, but I think them in no way inferior to the best that have been produced from unadulterated California petroleum. The best refined California petroleum that I have made either in California or at the East, as also the best that I have seen from other sources, fails to produce a light of such intense whiteness as the best refined Pennsylvania oils, although they are quite equal to the average upon the market either in San Francisco or New York.

It is my opinion, although it may not be a correct one, that this difference is due to admixture of the "benzole" series, or perhaps some other containing a large amount of carbon in proportion to hydrogen, in such quantity as to render the combustion incomplete, and thus give rise to a yellow flame. Had time permitted, it was my intention to have determined the correctness of this view; a subject which I hope to investigate at some future day.

I do not profess to be a judge of the *qualities* of lubricating oils. Those that I have made are of fine appearance, and I see no reason why they should not be as valuable as any others manufactured *pure* from California bitumens.

I have subjected both crude and distilled products to a temperature of —8° Fahr. Even at that degree of cold they failed to exhibit any traces of paraffine or of any other solid substance. The oils became more dense, but remained perfectly fluid. Pennsylvania petroleum of ordinary density would at that temperature have given a considerable quantity of the crystalline scales of paraffine; and its distillate of a density of 20° Baumé would, when subjected to that degree of cold, have become semi-solid.

I consider the absence of paraffine to be a great impediment to the manufacture of good lubricating oil from this source, without admixture of tallow, stearine, or some fixed oils; but if those who use them find them profitable and useful, it is perhaps the only indorsement required.

The time allotted me for the prosecution of this work did not admit of an extended examination of the elementary constitution of either the crude bitumens or the products of their manufacture. I have, however, been able to obtain some results which are very interesting, as pointing to causes which produce the change from petroleum to asphaltum.

I first estimated the specific gravity of the different samples by weighing both oils, malthas, and asphalts. My results are as follows: —

No. I.	No. II.	No. III.	No. IV.	No. V.	No. VI.	No. VII.
.9023	.8932	.9184	.9906	1.0042	1.256	1.4188

Nos. II. and III. are the same as when estimated by myself in California. It will be observed that No. I., although obtained from the extremity of a tunnel fifty feet in length, and running thence to the tank through closed pipes, is a more dense oil than No. II., which was taken from a surface outcrop.

When I obtained the specimen marked No. I., it was my intention to procure a sample of the lightest oil at that time procured in Southern California. I was assured by the person in charge of the property, that the oil selected was the lightest at that time produced upon it; but he was mistaken, as I received a sample while on the Ojai Ranch from the Hayward Petroleum Company's estate, that was of specific gravity 30° Baumé, or .875; a lighter oil than No. II. The specific gravity of the maltha No. IV., after having been heated so as to expel all the volatile impurities, was identical with that of the crude material, .9906, the lighter air and gas exactly counterbalancing the heavier water, so as to produce a mixture of uniform weight. I also estimated the specific gravity of the asphalts from La Goleta, etc., as follows: —

La Goleta.	Santa Bárbara.	Ojai Ranch (pure).
1.4886	1.653	1.2092

One and two tenths is the number given in the books as the specific gravity of asphaltum.

These different varieties of bitumen may be arranged thus, according to their density: —

Sp. gr.
No. 1. 1.6530, asphalt of Santa Barbara, .8941 sand.
" 2. 1.4886, asphalt of La Goleta, .4489 "
" 3. 1.4188, asphalt of Ojai Ranch, No. VII.
" 4. 1.2560, asphalt of Ojai Ranch, No. VI.
" 5. 1.2092, asphalt of Ojai Ranch, nearly pure.
" 6. 1.0042, maltha of Ojai Ranch, very dense.
" 7. .9906, maltha of Ojai Ranch, average.
" 8. .9184, petroleum from Cañada Larga Spring.
" 9. .9023, petroleum from Hayward Petroleum Company's tunnel.
" 10. .8932, petroleum from Pico Spring.
" 11. .8750, petroleum from Hayward Petroleum Company examined by me on Ojai Ranch.

These samples fairly represent the range in specific gravity of Southern California bitumens.

I next subjected the oils to distillation in the apparatus used by Mr. C. M. Warren, in order to obtain the more volatile portions in a greater or less degree of purity, for subsequent analysis, and comparison with the light oils from Pennsylvania petroleum. The bath was heated to 200° C., and acted in such a manner that all products condensing at or above 200° C. would be condensed and run back into the retort, while the more volatile vapors passed on through a worm to a receiver. The oils yielded as follows: —

	No. I.	No. II.	No. III.
Boiling-point,	182° C.	174° C.	182° C.
Boiling rapidly,	185° C.	176° C.	
Boiling constant,	276° C.	271° C.	273° C.
Quantity coming over under 150° C.,		trace.	
" " " " 200° C.,	78.25 c. c.	55.25 c. c.	34.5 c. c.
Color of distillate,	colorless,	colorless,	yellow, from sulphur.
Sp. gr. of distillate,	.80	.80	.81
Percentage of distillate,	26.08	18.41	11.50

No. III. contained sufficient sulphur to form a deposit in the neck of the retort. These results exhibit the following peculiarities, namely, the oils have very high boiling-points; they also commence to distil at a very high temperature. It is also somewhat remarkable that No. I., although more dense, and boiling at a higher temperature than No. II., furnishes a very much larger percentage of light oils. This is no doubt due to the fact that the bulk of the heavy oils in No. II. are lower in the series, and consequently the average density and boiling-point is much lower. This is also proved by the fact that by distillation under the same degree of pressure the yield from No. II. is very much larger than that of No. I. The yield and specific gravity of the distillate from No. III. would also indicate that the lightest oils were almost, if not entirely, wanting in that specimen.

These distillations furnished products which I hope at some future day to be able to separate in a state of purity, in order that I may analyze them and determine, if possible, the identity or difference between the homologous series of hydrocarbons existing in California bitumens on the one hand, and on the other, those existing in

Rangoon and Pennsylvania petroleums and the distillates of Boghead coal and albertine. This, however, is more a subject of scientific than of economic interest.

I have also determined the amount of nitrogen contained in the different samples of petroleum and maltha. These determinations gave as a mean of two determinations, —

$$\left.\begin{array}{r}1.140\\1.079\end{array}\right\}1.1095\text{ per cent for No. I.}$$

$$\left.\begin{array}{r}1.026\\1.007\end{array}\right\}1.0165\text{ per cent for No. II.}$$

$$\left.\begin{array}{r}1.088\\1.083\end{array}\right\}1.0855\text{ per cent for No. III.}$$

$$\left.\begin{array}{r}.545\\.584\end{array}\right\}.5645\text{ per cent for No. IV.}$$

.1912 per cent Pennsylvania petroleum.

I have been unable thus far to find any record of prior determinations of nitrogen as a constituent of petroleums or malthas. Delesse[*] notes 1.54 parts in one thousand for "elaterite" or elastic bitumen, from Derbyshire, and 2.56 parts in one thousand for bitumen from the lake of "Poix à la Trinité." This is a little more in one instance, and a little less in the other, than is found in Pennsylvania petroleum.

These results would seem to indicate that the change from petroleum to asphaltum is attended with loss of nitrogen, with deposition of carbon, and consequent thickening of the fluid. I cannot believe that this change is in any great measure, if at all, due to the action of the sun's rays; as maltha has been found in varying degrees of density at from ten to more than four hundred feet from the surface. This change appears to me to be analogous to that by which balsams become resins, or by which drying oils become solid, assisted perhaps by the decomposition of unstable nitrogenous bodies, which by deposition of solid carbon mechanically thickens the mass. This view is supported by the fact, that the odor of the malthas is putrescent, instead of balsamic like petroleum; and also that this change only takes place when the oils are placed in contact with oxygen. That very little oxygen is required for this purpose is proved by the fact that the small amount of atmospheric air conveyed to very considerable depths by the infrequent rains of Southern California is still sufficient to effect the change.

This comparatively large amount of nitrogen points strongly to the animal kingdom as the origin of these petroleums. The estimation of nitrogen has been almost entirely overlooked in previous analyses of petroleum, having been estimated with the oxygen as oxygen, by deduction of the sum of the carbon and hydrogen from the whole amount.[†] For this reason I have no results with which to compare my own, and they are too meagre to enable me to form opinions in regard to this subject susceptible of general application. I hope, however, at some future day to further prosecute this research, and if possible throw some additional light upon the now obscure question of the origin of petroleum.

The California bitumens in all forms contain a small quantity of sulphur.

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[*] "De l'Azote et des Matières Organiques dans l'Ecorce Terrestre," par M. Delesse, Paris, 1861, pp. 172, 173.

[†] Hunt's Essay on Petroleum, "Chemical News," Vol. VI. p. 35. July 19, 1862.

(SECTION II. JANUARY, 1871.)

WHILE engaged in 1866 – 67 in conducting the researches upon California bitumens, the results of which have been embodied in a former report to the State Geologist, I was repeatedly impressed with the remarkable differences that are found to exist between California and Pennsylvania petroleums when those oils are subjected to processes of manipulation which are identical.

These differences were much less marked in the substances themselves than in the products derived from their decomposition either by distillation or by the action of chemical reagents, especially when such action rendered oxidation possible. These phenomena strictly corresponded with those which were the results of natural causes, as observed by myself in California, and led to the formation of a number of hypotheses by which to account for the varied forms under which bitumen appears in that region.

The well-known fact that oxygen is set free from growing plants as ozone suggested the possibility that the comparatively rapid oxidation of the California oils was due to the large amount of ozone set free during the period of vegetable growth, and conveyed by meteoric water to great depths, through the broken and porous strata of that region. This hypothesis, however improbable it might appear, led me to ascertain what the action of ozone might be upon the California and Pennsylvania oils.

Three methods are in use for generating ozone. The best, but least convenient process is that used very extensively and almost exclusively by Schönbein, by electrizing a current of air or oxygen gas. This process is expensive both in apparatus and manipulation, especially when the research is not likely to be prolonged. I therefore first attempted to generate the ozone by means of the slow oxidation of phosphorus. This method I found to be impracticable, as the phosphorus invariably took fire after exposure for some time to a stream of air, and more or less of phosphorous compounds were conveyed to the oil. I then had recourse to the process of generating ozone by the action of sulphuric acid on pure and dry crystallized permanganate of potash. This process, with proper precautions to insure freedom from particles of the brown oxide of manganese, proved exceedingly satisfactory.

The several varieties of California oil were subjected to the action of this reagent with results which varied but slightly in the different samples, but which were proportioned in degree to the length of time during which the experiment continued. The time was varied from two to five days. The oxidation was in every case increased by prolonged action of the ozone, but not in the same ratio, as the amount of ozone passed through the oil per hour decreased as the time was extended. A few hours only were sufficient to cause a slight deposit of black solid bitumen around the extremity of the tube by which the gas entered, and as the action was prolonged, this substance appeared on the bottom of the vessel containing the oil, the amount increasing until, in the most extended experiments made, the bulk equalled about one third that of the oil. On freeing this deposit from adhering oil by bibulous paper, it appeared as a brilliant, jet-black, semi-elastic solid, resembling the purest specimens of recently formed natural asphalt that had not been melted. It was easily fusible at the temperature of boiling water, and upon cooling became again solid, and more brittle than at first. The solid products obtained as a result of all of the experiments made were alike in physical properties and appeared to be identical.

Experiments were also made to ascertain the effect of ozone and chlorine combined. The reagents used were impure commercial permanganate of potash, containing a portion of undecomposed chlorate, and sulphuric acid. The oxidation in this case was effected more rapidly, but the products were not to be distinguished physically from those obtained in the first instance.

The effects of prolonged transmission of common air were also studied, but they were not of such a character as to be very satisfactory. The time in one instance was fifty days. No deposit was formed which admitted of separation, and the thickening of the oil seemed on the whole to be due more to evaporation than to oxidation. However, I did not deem these experiments conclusive, as the time allowed bore no adequate proportion to the difference observed in the energy with which ozone and chlorine, on the one hand, and common air, on the other, effect the oxidation of substances submitted to their action.

A sample of oil from Oil Creek, Pennsylvania, was then subjected to the action of both ozone and common air. No appreciable difference could be detected between the products of these experiments. No blackening of the oil occurred in either case. The oil, however, diminished rapidly in bulk, and at length became somewhat gelatinous in consistence, appearing in some respects like paraffine, or, more strictly speaking, like a dense oil from which paraffine had been imperfectly crystallized.

A remarkable feature attending the transmission of the chlorine through the California oil was the formation of minute particles of very dense, difficultly soluble, and fusible bitumen, resembling coal rather than asphalt.

The observations made during these simple experiments led me to make the attempt to classify bitumens, and the conclusions at which I arrived were embodied in a paper read at a meeting of the National Academy in August, 1868. In order to secure to myself a claim to priority in the results of this research, I made public at that time, with the permission of the State Geologist, a summary of the experiments here described in detail, and stated their relation to the subject then under discussion. Facts which have since come to my knowledge have somewhat modified my views as then stated, but the main question to which they relate, and which was not then touched upon, still demands attention, and exhibits one of the most enticing and extended fields for chemical and technical research, of which I have any knowledge.

These experiments proved beyond further controversy, what had before been stated as probable, if not certain, that the bitumens of California and Pennsylvania were totally unlike in proximate, if not ultimate composition. They further proved that, little as is known of the composition of the Pennsylvania oils, still less is known of that of those of California, and indicated that possibly the latter may contain an entirely new class or classes of substances, with new applications in the arts and domestic life, possibly creating new industries and new interests both to individuals and the State.

While any immediate benefits accruing to the State would no doubt be reached through developing the results that I obtained in my technical examination, conducted in 1866 – 67 to a conclusion so satisfactory to myself, I became convinced that no less, and probably more, important results might be reached by a thorough chemical study of the California bitumens. This study seemed to me to be embraced under several heads, or to be susceptible of prosecution along several different paths, each of very great interest and importance to science, and each perhaps affording equal probability of furnishing valuable results in the interest of technology.

Following the suggestions of my experiments with ozone, I determined to investigate the formation of artificial asphalt and ascertain its relation to the natural substance. This research would involve the solution of the question whether oxygen is added or hydrogen subtracted from petroleum by the process, or both.

To do this I determined that it would first be necessary to establish the percentage composition of several representative or typical varieties of crude petroleum, e. g. those of Northern and Southern California, Pennsylvania, Canada, Italy, etc.

Secondly, to subject those different varieties to the action of ozone under conditions as nearly identical as possible.

Thirdly, to study the solid residues of such action, and establish their identity (if such identity exist) with native asphalts or other solid hydrocarbons.

Fourthly, to study the liquid and volatile products of such decomposition.

Another research would embrace the fractionation of California petroleum, and the investigation of the products obtained. Still another, the fractionation of the pressure distillate of California petroleum, and investigation and comparison of the products.

A field for investigation is thus opened which is at present absolutely unexplored, and which is one of the most inviting which chemistry now presents, promising as abundant harvests to science and technology as any of which I have any knowledge.

Through the facilities afforded by the California Survey, I have been enabled to take provisionally, to some extent, the preliminary steps to the first research above described.

While attempting the ultimate analysis of several different samples of petroleum, I repeated the experiments previously made, with corresponding results, and thus obtained a considerable quantity of the artificial asphalt. I also discovered that carbonic acid was present in considerable quantity in the gaseous products after passing through the oil.

The ultimate analysis of these oils presents an exceedingly difficult problem. Believing Warren's process to be the best, I constructed apparatus for analysis in pure oxygen gas, by his method. I soon found that the substances with which I had to deal were so different from anything of which he had recorded an analysis, that the apparatus, as described by him, needed several very important modifications. The three months and a half that I devoted to this work were fully half devoted to the perfection of this apparatus, so as to enable me to obtain satisfactory results. This use of my time was entirely unavoidable, as no reliable analyses of such substances are on record, and no apparatus is described, so far as I can learn, at all comparable to Warren's for such work. This apparatus as described is admirably adapted to the analysis of such oils as are completely volatile at any temperature below that at which they will combine with oxygen, but for oils or mixtures yielding oils volatile near the red heat it is no longer applicable. It was found, after repeated trials, to be impossible to so regulate the distillation of the oils at high temperatures as to insure their combustion in pure oxygen, without the aid of asbestus through which grains of black oxide of copper were scattered. These grains were reduced by the hydrocarbon gases, and again oxidized as soon as they were reached by free oxygen. With this arrangement the combustion was easily managed. The greatest difficulty was occasioned by the constant tendency of the mixed oxygen and hydrocarbons to explode, when the temperature was sufficiently high to volatilize the more dense portions of the crude oil. This trouble was removed by making a sort of circular brush, similar to a test-tube brush, of platinum wire and very fibrous and tough asbestus. The platinum-boat containing the oil was first introduced, and then the brush, in such a manner as to fill the tube above it. This contrivance prevents the flame from running through the tube and burning all of the mixed gases at once. The mixture with this arrangement burned quietly, whatever the temperature might be at which the hydrocarbon became volatile.

A still further trouble was experienced in weighing the lighter oils and conveying them to the combustion-tube. Several of the oils subjected to analysis were so volatile that the lighter portion evaporated in very appreciable amount in the few minutes that elapsed between weighing the oil and introducing it into the combustion-tube. I found no difficulty in weighing the heavy oils in an open platinum-boat, and burning them with the asbestus brush just described; but I found it necessary to weigh the lighter oils in small glass vessels, which were made by drawing apart very thin glass tubing, about an eighth of an inch in diameter, leaving the tube of its full size for about a quarter of an inch in length, and tapering at both ends to a capillary bore, which might be instantly closed by fusion. These tubes were first weighed, and after being filled by suction, were hermetically sealed by fusing the fine capillary extremities. These may be kept for an indefinite period in this condition without injury, and when required for combustion may be broken and immediately transferred in a platinum-boat to the tube without loss.

These tubes I found very much more readily made, and much more easily and rapidly filled than bulbs. Another objection to bulbs for this purpose is, that they require to be heated more or less in filling, which, in a highly complex substance like crude petroleum, would occasion an evaporation of the lighter portion, leaving an oil in the bulb more dense than the original oil, and containing a larger percentage of carbon.

The process and apparatus, thus modified, were found to be susceptible of great accuracy, especially in the estimation of the hydrogen. The percentages of the hydrogen obtained from the same oil were found to correspond to a remarkable degree, but the results of the estimation of the carbon were in many respects less satisfactory. The following analyses will serve to illustrate the different degrees of exactness with which analyses of hydrogen and carbon may be repeated.

The first sample was from the Sciota Well of West Virginia, furnished me by Professor Andrews of Marietta College, Ohio: —

	I.	II.	III.	Mean.
Hydrogen . .	13.035	12.821	12.932	12.929
Carbon . . .	86.865	86.065	86.936	86.622
Total . .	99.900	98.886	99.868	99.551

The next sample was of "Mecca Oil," furnished me by by Dr. J. S. Newberry of the Columbia College School of Mines: —

	I.	II.	III.	Mean.
Hydrogen . .	13.024	13.118	Lost.	13.071
Carbon . . .	86.223	86.410	86.317	86.316
Nitrogen . .	.230	.230		.230
Total . .	99.477	99.758		99.617

The nitrogen was determined some time previously by the soda-lime process, and the .230 is a mean of three analyses.

The next sample was from the Cumberland Well, West Virginia, furnished me by Professor E. B. Andrews. The nitrogen had been previously determined to be 0.54 per cent.

	I.	II.	III.	IV.
Hydrogen . .	13.269	13.148	13.563	13.457

The carbon varied from 85.2 to 86.1.

The next sample was from the Hayward Petroleum Company's tunnels, and when last analyzed for nitrogen gave .487 per cent: —

	I.	II.	III.	IV.
Hydrogen . .	11.878	11.830	11.762	11.809

Carbon varied from 83 to 89.

A sample of commercial Pennsylvania oil, from the Downer Kerosene Oil Company: —

	I.	II.
Hydrogen . .	14,594	14,529

This variation in the carbon has been attributed, by Professor C. M. Warren, to the formation of carbides of copper by reduction of the oxide of copper in the presence of an excess of carbon. This explanation appears very plausible, especially when considered in relation to the results obtained by him without the use of copper oxide, and those obtained by myself with its use. I found that whenever a maximum percentage of carbon was obtained a minimum quantity of copper oxide was reduced, and vice versa, and that no amount of heating or of free oxygen would obtain from the combustion the requisite amount of carbonic acid in the latter case. I found it to be an exceedingly difficult task to conduct the combustion of these oils without the aid of the copper oxide or some similar easily reducible substance, and I was about to commence the use of potassic chromate in place of it, when my work was suspended in consequence of my appointment to a Professorship in Washington College, Pennsylvania.

The analyses of the oils which I made demonstrated the fact that crude petroleums are not of uniform ultimate composition, but that the proportion of hydrogen increases as the density decreases, and that the carbon increases in an inverse ratio. These results are contrary to the hypothesis of Bischof and T. Sterry Hunt, who assume that petroleum has the general formula * $C_n H_{2n}$.

These results, meagre though they may appear, are an absolute necessity as preliminary steps in the successful prosecution of this research. Of the value of these investigations to the State but little need be said. The vast accumulation of the raw material in the southern counties, which though proved of but little value in its application to purposes and processes at present well known, is nevertheless an immense storehouse of material force, which only needs to be studied, to be found of the greatest value as a source of fuel, if nothing more. It must be constantly borne in mind that this variety of bitumen is essentially a new substance of unknown applications, which may be discovered either by research and comparison with other and better known varieties, or by the longer, more laborious, and expensive process of empirical experiment. That these deposits of hydrocarbonaceous material will in no far distant future prove of enormous value to the Pacific Coast cannot be doubted for a moment. The great distance from the coal-fields of the Eastern States, and the limited deposits and inferior quality of the coal found upon that coast, will cause, as the population increases in that region, a demand for a more accessible and abundant supply of fuel. Whatever disappointments and failure may have attended attempts to develop these resources upon a scale and by methods wholly applicable to other regions and a very different material, no candid and properly informed person can for a moment doubt that a reasonable degree of success will attend attempts to develop these resources of the State, when a wild fever of speculation shall have been succeeded by a desire to obtain from a new and untried substance such products as by patience and experiment it may be found to supply for the wants of mankind.

This field of study and experiment is open and unoccupied, and with the work already done may be made to yield profitable results with as great a degree of certainty as can ever be predicated of scientific research. No more forbidding problem could be placed before any one than the investigation of the coal-tar of the gas-house, yet how immense the value of the results obtained, how far reaching in their effect upon the industries of the world. It is the hope of those who appreciate the value of scientific and technical research, that this investigation will not be allowed to end at its present stage, but that it may be prosecuted to such results as will confer value upon property now considered worthless, and command the respect of those whose failure to realize unwarrantable expectations has led them to overlook more modest worth.

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* Chem. and Phys. Geology, I. Chem. News, VI.

G.

REPORT ON AN EXAMINATION OF THE QUICKSILVER MINES OF CALIFORNIA.

BY W. A. GOODYEAR.

(MAY, 1871.)

I LEFT San Francisco on the 24th of March, 1871, and went to New Almaden, where I remained until April 2, inspecting the Mine, the Reduction Works, the Guadalupe Mine, etc.

On the 2d of April I returned from New Almaden to San José, and visited what is known as the San Juan Bautista Mine, in the hills of the same name, about four miles south of San José. The evening of the same day I went to Gilroy, and reached New Idria on the afternoon of the 4th.

I remained here until Saturday, the 15th, visiting in the mean time, besides the New Idria mines and works, several other localities in the adjacent region, and gathering sundry notes, which I shall also present in full.

NEW ALMADEN MINE.

The country about New Almaden appears to me to be entirely metamorphic. I saw nothing whatever which seemed to me to be igneous in its origin, though some of these rocks have been called "trap" by writers who described the mine in its early days. Nor did I see anything at the mine which bore any resemblance, so far as I could see, to a regular mineral "vein" of any kind whatever, although I find that the mine was stated by one writer, in 1861, to be, "without question, a true or *fissure* vein." It appears to me to be anything but a vein, and anything but regular.

The stratification in this region is in general almost completely obliterated.

On the afternoon of Sunday, the 26th, I took a ride some four or five miles westerly up Alamitos Creek, on which is situated the Hacienda, and which is a branch of the Arroyo Seco, which last is a branch of Los Capitancillos Creek. On this trip the only rocks I saw were serpentines, jaspers, and metamorphic sandstones and shales. The quantity of serpentinoid rocks is large.

The form and general appearance of the Mine Hill are well known. The earliest workings at the New Almaden Mine were close about the highest point in the crest of this ridge, which point is said to be about fourteen hundred feet above the level of the Hacienda, which is about a mile distant.

The present workings in this mine extend over a large area, and their extreme limits would be barely included within a rectangular block about 2,100 feet long from north to south, and 1,200 feet wide from east to west, and about 775 feet deep below the highest crest of the hill. They do not by any means cover all the area here indicated, but are very irregularly distributed within it.

These workings may be conveniently divided into three prominent clusters or groups, which I shall call respectively the Southwestern, or "San Francisco," Group, the Central Group, and the Northern Group.

The latter group may then be subdivided into the Northwestern Group, or the "Santa Rita West," and the Northeastern, or "Velasco," Group.

Towards the south these two sub-groups unite, and are then connected with the main central group by the "Great Santa Rita," which is said to have been the largest and richest "labor" ever found at New Almaden.[*]

It will be easily understood, I think, from the above description, that a horizontal plan of the Northern Group of workings, taken in connection with the Great Santa Rita itself, would have the general form of the letter Y, the two branches of the letter lying respectively towards the northwest and northeast, while the Great Santa Rita, which corresponds to the lower portion of the letter, forms also an almost complete connection between the Northern Group of workings and the Great Central Group itself.

If the southwestern corner of the rectangular area, which I have indicated above as covering the entire workings of the mine, be taken as the origin of a system of co-ordinates, then the co-ordinates of some of the leading points in and about the mine will be approximately as follows: —

	N.	E.
N. W. end of San Francisco Group	350 feet.	100 feet.
S. E. " "	20 "	550 "
S. E. end of Great Santa Rita	1,250 "	630 "
N. W. " "	1,550 "	550 "

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[*] The following additions and corrections to this part of Mr. Goodyear's report are extracted from a letter of J. B. Randol, Superintendent of the New Almaden Mine, to Mr. Goodyear himself, dated January 17, 1872: —

"The Santa Rita was not the largest and richest labor ever found at New Almaden; the Great Ardilla surpassed it. Nor is it probable 'that the average yield of all the ore from this labor was not less than twenty-five per cent,' nor is it probable that 'any of it yielded as high as sixty to seventy per cent.'

"I write this at home, where I have only the Report for 1866. In that year the mine produced 53,754 cargas, of which the Santa Rita gave 22,949 cargas, leaving, as the product of all the other workings, 30,805 cargas. In addition there was gathered of 'tenero' 17,729 cargas, estimated to yield from four to four and a half per cent. This was all reduced in the furnaces, and made a total, counted as ore, of 71,483 cargas, or 21,445,100 pounds. This, with 5,440,200 of 'tierras,' gave as the furnace product, 2,656,539 pounds of quicksilver.

"The tierras, estimated at three per cent, gave	163,206 lbs.
The teneros, at four per cent, gave	212,748 "
The Santa Rita product, 22,949 cargas, at twenty-five per cent, gave	1,721,212 "
The product of all the other workings, 30,805 cargas, gave	559,373 "
Total	2,656,539 lbs.

"That is, to allow twenty-five per cent for Santa Rita ore makes the average of all the other rich mine ore to be about six per cent."

	N.	E.
Central point of branching between the Great Santa Rita and the Northwestern and Northeastern Sub-groups	1,600 "	550 feet.
N. W. end of Santa Rita West or Northwestern Sub-group	1,900 "	40 "
N. E. end of Velasco Sub-group	1,800 "	1,150 "
Most northerly point of Velasco Sub-group	2,100 "	800 "
Main shaft in Central Group of workings	800 "	600 "

In addition to this, it may be said that the Great Central Group itself would be included within the outlines of a smaller rectangle about 500 feet long by 350 feet wide, and situated between the limits, — N. 700 feet and N. 1,200 feet, — and E. 450 feet and E. 800 feet.

Furthermore, at the northwest extremity of the Santa Rita West there is a piece of ore-bearing ground, which is now being worked, and which I shall have occasion to speak of again hereafter, which is something over three hundred feet long in a northeasterly and southwesterly direction (so far as yet developed), and which extends a little farther to the west than any other portion of the mine. The co-ordinates of the extremities of the present workings in this ground are nearly as follows: —

S. W. end	N. 1,900 feet.	W. 50 feet.
N. E. end	N. 2,050 "	E. 350 "

I should mention that these figures are taken from the maps in the company's office at the mine. And, before going farther, I will also give the relative heights of certain points in and about the mine, to some of which I shall have occasion to refer again. The figures indicate the depths of the points mentioned below the reference plane, which is at the apex, or highest point, of the Mine Hill: —

Mouth of Main Tunnel	331 feet.
Rails in Main Tunnel at mouth of main shaft	323 "
Ten-Fathom Level	383 "
Twenty-Fathom Level	443 "
Bester's Level	510 "
Ardilla Level and Santa Rosa Level, both	570 "
Relief Level	670 "
The Day Tunnel, which is the present lowest level in the mine	775 "

The Southwestern, or San Francisco Group of workings, occupies a belt of ground running northwesterly and southeasterly, and nearly straight for several hundred feet, though the workings themselves are exceedingly irregular in form and outline, as they are in every portion of the mine.

The Central Group of workings, in conjunction with the Great Santa Rita labor, has probably furnished more than four fifths of all the quicksilver ever taken from the New Almaden Mine.

The Main Tunnel runs northwesterly into the hill for a distance of 775 feet to the main shaft. This tunnel is straight, large, and well timbered, being ten feet wide and ten feet high, the timbers being arched at the top. It is also provided with a good track of three-feet gauge, laid with T-rails.

The Main Shaft does not rise to the surface of the ground, but is sunk from the level of the Main Tunnel; and its mouth in this tunnel is nearly beneath the highest point of the Mine Hill.

The laborers employed in the mine are still very largely Mexicans, and many of the terms here used in connection with the work are Spanish words. I will explain such terms as I use them.

Each chamber of ore in the mine, i. e. each separate "working," is called a "labor." And most of the larger and more important "labores" have had special names given to them for convenience of reference.

The most important labores in the Great Central Group, the form and position of some of which I shall attempt to describe, have been the Buena Vista, the Dios te Guia, the North and South Ardilla, the Buenos Ayres, the Sacramento, the La Ventura, and the Far West.

These, except the Buena Vista, are all below the level of the Main Tunnel. The older workings above the level of this tunnel, though of considerable extent, and said to have been very rich, are now extensively caved together, and the greater portion of them inaccessible; and I obtained but little definite information respecting them. At this locality, however, rich ores were found almost continuously, all the way from the surface down to the deepest workings in this part of the mine, which are those of the Ardilla Level.

On page 68, Vol. I., after giving the space within which the workings up to that time had been mostly confined, it is stated that "this ore-ground dips to the north at an angle of thirty to thirty-five degrees, with the formation," etc. As a general statement, this was undoubtedly true at that time. The ore-ground in what is now this Central Group did have to the depth of some four hundred feet such a general dip to the north, though I do not understand exactly what was meant in that sentence by the phrase "with the formation"; for I do not know that I saw any definite stratification in the New Almaden Mine. But the very extensive developments which have been made since that sentence was written show that it no longer holds true as a general statement for the whole mine. Nor is it true of a considerable portion of the lower and more recent workings, even of this same Great Central Group, as will appear from what follows.

The Buena Vista was in the top of the Mine Hill, and I am informed by the Mining Captain that it, and the other workings generally above the level of the Main Tunnel here, had a general northerly pitch, as stated above. The Dios te Guia extended down below the level of the Main Tunnel with a similar northerly pitch to the depth of somewhere in the vicinity of five hundred feet below the apex of the hill, where, at a point about two hundred and fifty feet northeasterly from the Main Shaft, it connected with the North and South Ardilla and with the Buenos Ayres, etc. These labores, together with the Great Santa Rita, whence such enormous masses of rich ore were taken, were more or less nearly lenticular in form, though their length was often disproportionally greater than their width. From the point of connection just mentioned the South Ardilla ran southerly for several hundred feet, lying on the east side of the Main Shaft, and extending somewhat beyond it towards the south. Its width east and west lay nearly horizontal; but in the direction of its length north and south it was slightly inclined, rising at a very gentle angle towards the south. It therefore lay partially beneath the Dios te Guia, which came down from above with a much higher angle of pitch. From the same point of connection the North Ardilla ran for one or two hundred feet to the north, being simply a continuation of the South Ardilla in this direction and continuing, like it, to descend very gently towards the north. From the same point of union another body of ore curved around first to the west and then to the south, forming the Buenos Ayres, which ran back to the south beyond the shaft, but on the west side of it. This body of ore also dipped towards the west, where it curved, and beyond there it kept descending gently towards the south, thus forming, in connection with the South Ardilla, a sort of horse-shoe, of which, however, the eastern heel, formed by the South Ardilla, was considerably higher than the western one, formed by the Buenos Ayres.

La Ventura, the Sacramento, and the Far West were other extensive labores lying nearly horizontal and in the immediate vicinity of the Buenos Ayres, but west of it. All the labores here mentioned were extensive and very rich. But the largest and richest mass of ore ever found in the mine was, as already stated, the Great Santa Rita labor. This mass lay nearly horizontal, and was, as I am informed by the Mining Captain, about three hundred feet long, in a direction somewhat to the west of north, eighty feet wide, and thirty feet thick or high. It was worked out in about three years' time (from 1865 to 1868), and at an average expense of only about $1.25 per carga (300 lbs. Avoirdupois) for mining, and the average yield of all the ore from this great labor is stated to have been not less than twenty-five per cent of metallic mercury, while there were large masses of it which yielded as high as sixty to seventy per cent.* All these great chambers are exhausted now, and there is very little ore in sight in this portion of the mine. None of them extend much below the Ardilla Level. Some ore is still being taken from the Far West, but the quantity in sight here is not large, nor is its percentage value high.

The situation of the most important levels which have been driven in the mine, as nearly as they can be described without an accompanying map, is as follows: The Main Tunnel has been already described, its mouth being on the southeast side of the Mine Hill. From a point in the Main Tunnel three hundred and thirty feet from its mouth the San Francisco branch starts, and runs southwesterly on the same level, about seven hundred feet to the San Francisco workings.

From a point in the lower workings near the Main Shaft, the Santa Rosa Level (which, it will be remembered, is upon the same level with the Ardilla) runs also southwesterly a correspondingly greater distance to connect with the lower portion of the San Francisco workings. Running northerly from near the Main Shaft, the same level is called the Ardilla Level. It runs through the old Ardilla and the Great Santa Rita labores, and then forks at the northern end of the latter, one branch running northeasterly and the other one northwesterly, and both of them rather crooked for several hundred feet farther among the Northern Group of workings.

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* Compare statement of Mr. Randol on page 92.

The Relief Level starts from the Main Shaft, and runs first for three or four hundred feet straight northwesterly, beneath the prolongation of the course of the Main Tunnel, then runs two or three hundred feet a little to the east of north, then goes northwesterly again and curves about for several hundred feet farther, extending to the farthest workings of the Santa Rita West, i. e. to the most northwesterly limit of the present workings in the mine. This level, in going from the Main Shaft to the Santa Rita West, lies to the west of (and, of course, below the level of) the Great Santa Rita labor, and passes for a long distance here through entirely barren ground. It also has some minor branches, one of which I will mention, as it is some six hundred feet in length. Starting from what is called the Junction Shaft, it runs first some two hundred feet, a little east of north, lying here on the east of the Great Santa Rita labor, and then bears nearly due northwest for some four hundred feet more.

The Velasco and the Great Eastern are two other tunnels of less importance, and on different levels, which have been driven in respectively from the eastern and northern sides of the hill.

The mouth of the lowest level, i. e. the Day Tunnel, is on the northern side of the hill, in the same gulch as the mouth of the Great Eastern, but lower down. This level runs first in a direction about S. 25° or 30° E. magnetic, and straight for eighteen hundred feet to the Junction Shaft. Beyond here it bears more to the west, and continues on some four or five hundred feet farther, passing under the great chambers which were so rich above, and extending to a point beneath the western portion of the Far West workings.

But, though a portion of this level thus lies directly beneath what have been in the past some of the richest portions of the mine, yet in all this distance it has developed no notable bodies of ore. From a point about two hundred and fifty feet northeast of the Junction Shaft a branch of this level runs west some four or five hundred feet, connecting here with a shoot, down which the ore now furnished by the Santa Rita West is dumped from the Relief Level.

These are the chief and most important levels. But the minor drifts are very numerous and some of them quite extensive, and Captain Pearce (the Mining Captain) tells me that there are probably not less than ten miles altogether of underground railroad-tracks in the mine.

The northern portion or continuation of the Great Santa Rita labor bent somewhat to the eastward, and at the same time curved upwards toward the northeast, connecting here with the Velasco workings at a somewhat higher level.

The workings most closely connected with the Great Eastern Tunnel were also known by the same name, i. e. the Great Eastern workings. But these, as well as the Velasco workings proper, are all included in what I have here called the Velasco Sub-group, i. e. the eastern portion of the Northern Group. The chambers which have been worked out in this portion of the mine are numerous, and some are of considerable size, though all are very small in comparison with the great labores of the Central Group; while at the same time they are exceedingly irregular both in form and position, so that little can be definitely predicated of them in these respects, except that they were mostly confined within a belt of no great width, which ran northeasterly some hundreds of feet from the northern end of the Great Santa Rita labor.

A similar state of things appears to have existed also to a great extent in the western portion of the Northern Group, i. e. the Santa Rita West. But of the extreme northwestern portion of this group I shall speak again.

The San Francisco workings, as already indicated, lie at a considerable distance to the southwest of the Great Central Group, and are separated from it by a broad intervening mass of barren ground. They are pretty extensive, and are scattered through a belt between five and six hundred feet in length in a northwest and southeast direction. There is much irregularity here, too, though oftener than otherwise the different labores in this portion of the mine appear to have lain with their major axes approximately parallel to that of the belt which contains them; while it has been no uncommon thing for them to dip first southwesterly on going down, and then to double back underneath and dip northeasterly in their lower portions.

No large bodies of ore are in sight at present in this portion of the mine, though scattered parties are working here and there on threads and stringers, and getting in the aggregate considerable ore, which, however, is generally of a low grade. During the year 1870 these workings yielded over ten thousand cargas of ore, which was nearly one third of the total product of the mine in that year. But their yield has since fallen off considerably.

At the present time by far the greatest portion as well as the best quality of ore produced by the mine comes from the Santa Rita West. Here, in the extreme northwestern portion of the mine, there has been developed within the last five or six months a patch or belt of ore-bearing ground some three or four hundred feet in length, which, so far as developments yet extend, appears to curve in an arc convex to the northwest, and whose chord lies northeast and southwest, while the ore appears to pitch to the northwest and north.

This ground lies below the Relief Level, but the workings here do not yet extend so low as the level of the Day Tunnel. I visited this portion of the mine twice, and on the last occasion (March 29) I saw at one point some very rich ore, there being, I should judge, several tons of nearly pure cinnabar in sight. From this point they had worked southwesterly, at the time of my visit, something over two hundred feet and northeasterly one hundred feet or more, and taken out a large quantity of very fair ore. The quantity of good ore still remaining here in sight was also large, while its quality appeared to be improving, and I think that the prospects altogether in this portion of the mine were very good. It is certainly due chiefly to the development of this ground that the monthly product of New Almaden to-day is twice as great as it was for one or two months during the summer of 1870. This product fell in July, 1870, to 731 flasks, while in February, 1871, it was 1,425, and probably not far from 1,500 in March.

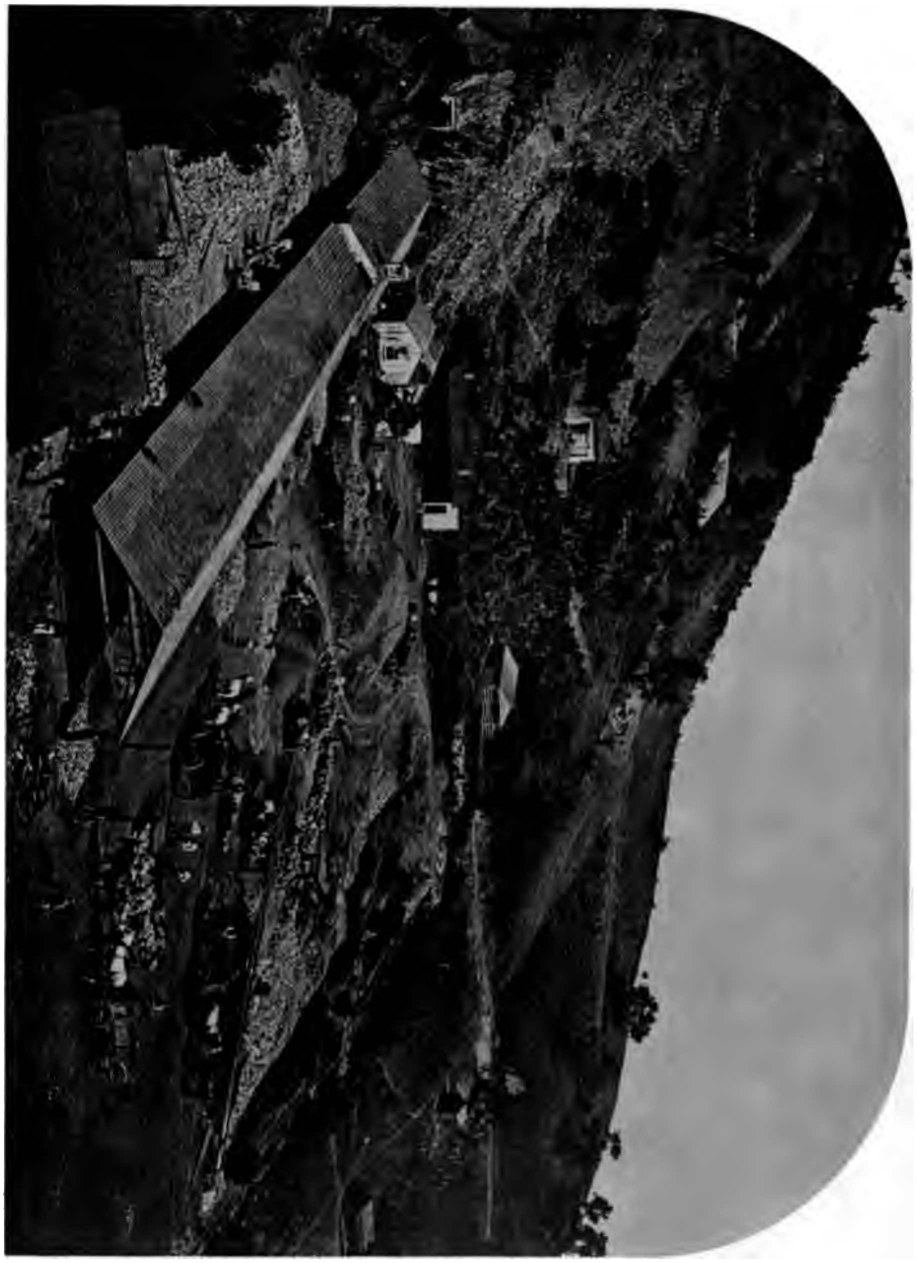
I have already stated that there appears to me to be nothing like a "vein" in the formation of the New Almaden Mine, although the miners usually call ore-bearing ground "the vein" wherever they find it, and any rock which resembles that which has been found to accompany ore "vein-rock." Furthermore, in talking either with the miners or the foremen of the mine, one hears constantly of the "alta," i. e. the hanging-wall, while a foot-wall is never mentioned by them. And the reason of this appears to lie in the curious fact, which seems to approximate a general rule throughout the mine, and was especially marked in the Great Central Group, that the larger and richer labores, whatever may have been their position, or in whatever direction they may have happened to strike and dip, have generally had rather well-defined and sometimes remarkably straight and smooth roofs. And, indeed, there are places in the mine where the roofs of the exhausted labores are for moderate distances as straight and smooth, and were, to all appearance, as sharply and well defined, as the walls of many a vein. Yet there is no constancy in the directions and positions of these roofs; but in different parts of the mine they strike and dip in every direction. Moreover, though these smooth roofs (which, wherever found, are called the "alta") are a very common, not to say a general, characteristic of the labores, yet it is very rarely, if ever, that any smooth floor can be found which might be called a foot-wall corresponding to the roofs.

I am, furthermore, informed by Captain Pearce, that, as a general thing, where these smooth roofs occur. the richest ore is found to lie immediately adjacent to them; while, in descending from them through the labores, the ore grows gradually poorer, and finally runs out altogether, the rock sometimes notably changing its character at the same time, and sometimes not appreciably so, and the floors of the exhausted labores being generally rough and uneven.

There are in different portions of the mine large quantities of a softish clay rock, which is in places filled with slickensides. Here and there also may be seen more or less serpentine. And there are great quantities of another variety of rock for which I have no specific name, but which I suspect to consist chiefly of an intimate mixture of clayey matter with silicate of magnesia and more or less quartz. This rock varies greatly in hardness, and often forms the roofs of the labores. I found in places also some well-characterized grayish sandstone, which, though somewhat metamorphosed, still retains perfectly its granular texture. But the quantity of this last is small. But very little cinnabar has ever been found here in any of the above rocks.

It is unnecessary for me to describe here the well-known "quicksilver rock," which forms the croppings at the summit of the hill. And I will only note that it appears to have been all more or less decomposed and altered by atmospheric influences, and is generally more or less stained, and sometimes deeply so, with oxide of iron.

But deeper in the mine and beyond the reach of atmospheric influence, the rock which has generally been found to accompany and constitute the gangue of the richer masses of ore is of a bluish-gray color, not very hard; it appears, I think, to have been once a sandstone, though its original character is now considerably disguised. It is filled with streaks and threads of various mineral substances, among which calcite is most prominent and plentiful. But there are also numerous and generally very thin streaks of rather a softish substance, which resembles serpentine in appearance, and possesses a bright green color, which I suspect to be due to sesquioxide of chromium. This rock also contains many vugs, or cavities, lined with



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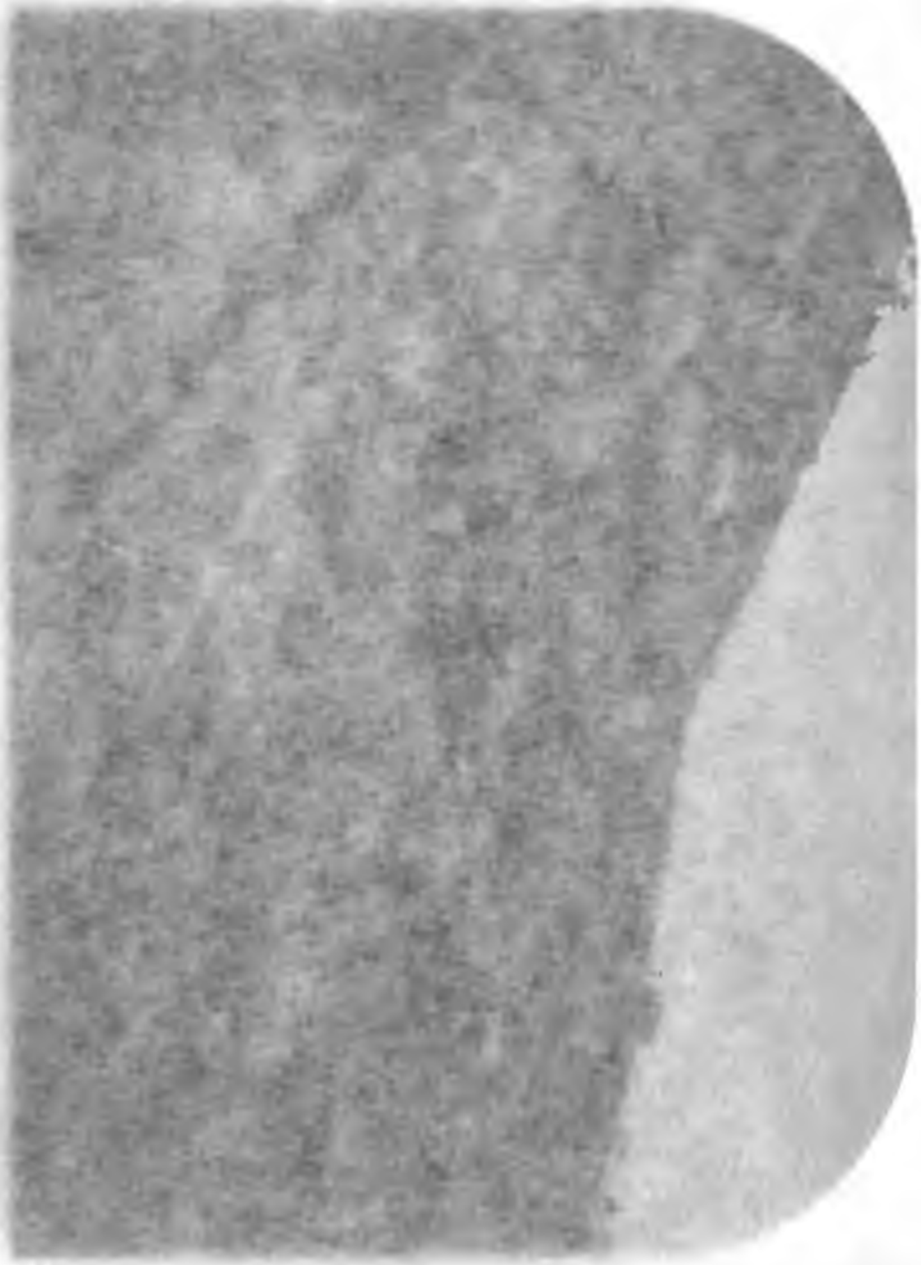
NEW ALMADEN MINE, THE PLANILLA.



crystals, which are generally calcite in the form of "nail-head spar," and often beautifully bright and clean, forming handsome specimens. But it is not uncommon to find some of these vugs lined with crystals of quartz instead of calcite, and sometimes the same cavity is lined partly with calcite and partly with quartz, both minerals being separately and beautifully crystallized. Moreover, it is not uncommon to find little globules and bunches of black and pitchy bituminous matter scattered about among the brilliant crystals which line these cavities.

The cinnabar at New Almaden is very rarely found in distinct crystals, but almost always either massive or compact-granular, the texture in the latter case being, however, more or less distinctly crystalline. Iron pyrites occurs here and there in the mine; but its quantity is small. Sulphurets of copper and arsenical pyrites have been stated to occur here also. But I saw none of these.

Most of the work in and about the New Almaden Mine is done by contract. The ore, as it comes from the mine, goes first to the "planilla," or sorting-floor, where it is all carefully sorted by hand, and the refuse thrown away. The ore, extracted by each little party of miners, is kept by itself in separate heaps on the planilla till it has been sorted and weighed. The miners are then paid a certain contract-price for each carga (300 lbs.) of assorted ore. The sorters are also paid per carga, the price for sorting ranging at present from twenty-five to fifty cents per carga, according to the quality of the ore.

Formerly the miners used simply to break the ore in the mine, the Company taking it from them at the face of the workings. Now, however, they are obliged to pack the ore out of the labores, and deliver it on the levels traversed by the cars which carry it out of the mine. A common price paid to the miners is $ 2.00 to $ 2.50 per carga of assorted ore. But this price ranges all the way from $ 1.50 to $ 5.00 or even $ 6.00 per carga, according to circumstances. And a portion of the Great Santa Rita labor was mined for as low a price as seventy-five cents per carga. After the coarser portion of the ore, as it comes from the mine, has been picked out and sorted by hand, the remainder is screened. That which is left upon the screen is then again carefully picked over by hand, while the finer portion which passes through the screen is called "tierras," and is mixed with clay and made into adobes, which are used with the lump-ore in charging the furnaces.

All the cars in the mine are pushed by hand, except those of the Day Tunnel, where mules are employed. In packing the ore out of the labores, the men make use of a sort of raw-hide basket, which they suspend upon their backs by means of a strap passing across the forehead, as the Indian squaws carry their pappooses. An ordinary load is about one hundred and fifty pounds; but some of the men take from two to three hundred pounds.

There is considerable carbonic acid in some portions of the mine, and there is occasionally more or less trouble with the ventilation on that account; but it is nothing very serious.

The Day Tunnel drains the whole mine, and the quantity of water running from it is quite small. No workings in any portion of the mine have yet extended below the level of this tunnel.

Nearly all the ore taken from this mine previous to 1865, as well as a large portion of that which has been extracted since, came from what I have called the Central Group of workings.

The Main Tunnel is said to be 1,070 feet higher than the Hacienda, i. e. the reduction works on Alamitos Creek. And as this tunnel is about 330 feet below the crest of the Mine Hill, it follows that the summit of this hill is about 1,400 feet higher than the Hacienda.

The ore is conveyed from the planilla of the Main Tunnel to the Hacienda by railroad, the cars descending the mountain by means of three successive automatic planes. The first, or upper one, of these inclined planes is close to the planilla of the Main Tunnel, and is 423 feet long. From the foot of this to the head of the second plane there runs a track with a gentle grade 3,902 feet long. The second plane is 610 feet long and from its foot to the head of the next one is 1803 feet. The third, or lowest, plane is 1,032 feet long, and from its foot to the furnaces is 1,930 feet more. The upper plane has a double track from top to bottom, and the two lower ones three rails each, with a turnout in the middle. From the planilla of the Day Tunnel the ore is hauled in wagons to the head of the middle inclined plane of the railroad, whence the cars carry it the balance of the way to the hacienda. From the mine to the Hacienda a fine wagon-road leads down the mountain with a grade of one in ten.

At the Hacienda Los Alamitos Creek runs nearly N. 40° E. magnetic. The reduction works here consist of seven furnaces with their condensing-chambers, etc., two of which (Nos. 1 and 2) are upon the right, or southeast, bank of the creek, while the remaining five are on the opposite side. These different furnaces, with their condensing-chambers, etc., vary more or less in the details of their construction and arrangement, but are all of them built to work upon the same general principle, which consists simply in the oxidation of the sulphur in the ore by means of the atmospheric oxygen, and the volatilization by heat and recondensation of the reduced mercurial vapors. This object is effected by exposing the ore in large chambers to a sufficient degree of heat, which is produced in a separate fireplace on one side of the ore-chamber, the heated products of combustion passing directly through the mass of ore and carrying out the mercurial vapors with them through the opposite side of the chamber and thence to the condensers.

The principle, as well as the general plan of construction of these works, is precisely the same as of those at Knoxville and at the New Idria Mine, and this is the only plan which has yet proved successful in reducing, upon a large scale in California, quicksilver ores of only moderate richness. The method of reduction by quicklime in cast-iron retorts has been extensively tried in this country, and discarded as being too expensive. Other methods have also been tried and rejected, and the only important variation now existing, so far as I know, upon the general style of furnace in use at New Almaden, is the furnace at the Manhattan Mine, near Knoxville, which I described in my report of our trip to Clear Lake.*

All the furnaces and most of the condensing-chambers at New Almaden are built of brick. It would be useless to attempt to describe minutely all these furnaces, and it is difficult to give a very clear idea of the details of their construction

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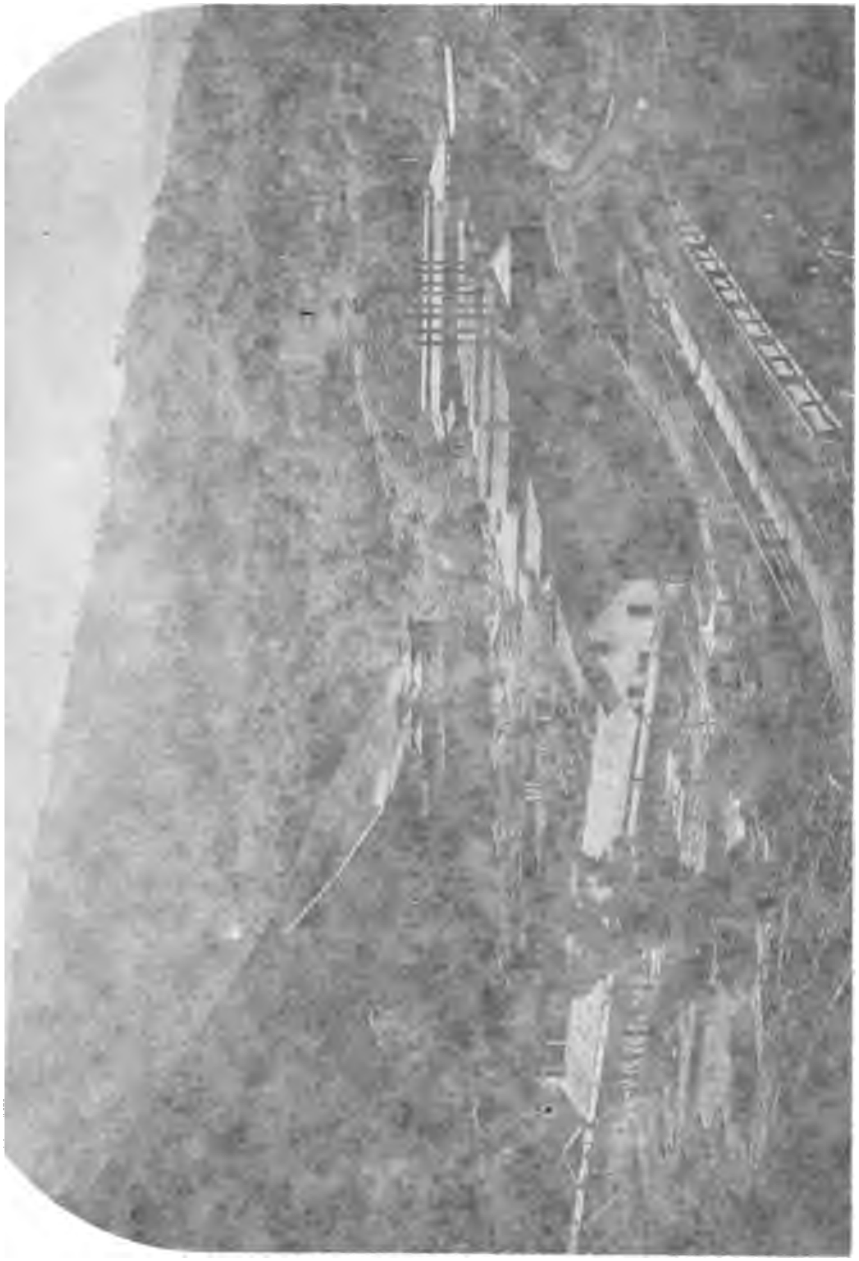
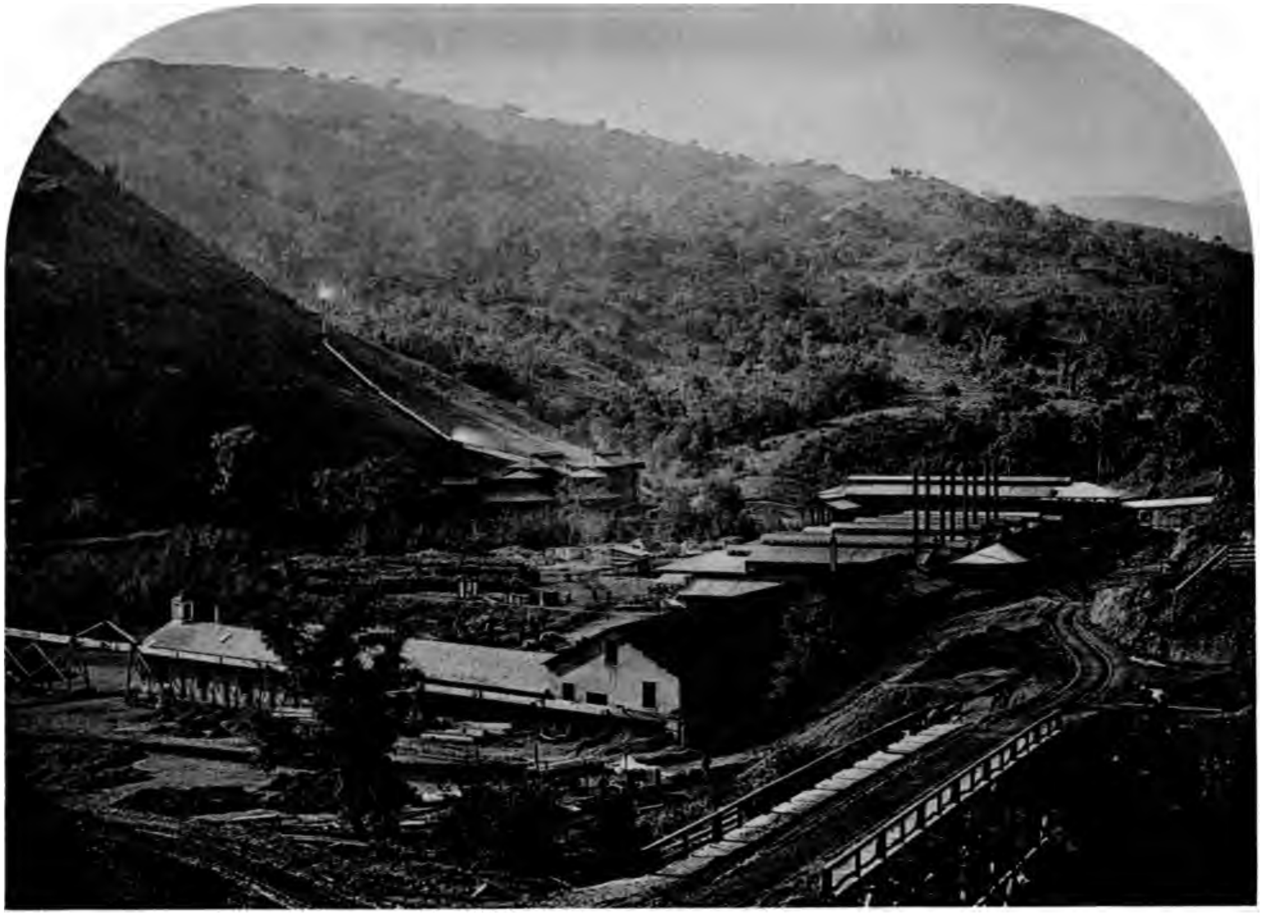
* See p. 126.





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NEW ALMADEN, THE HACIENDA.

without the use of plans and sections. For illustration, however, I select furnace No. 6, which is the largest and best approved of all of them, and will describe it in considerable detail, as clearly as I can without the aid of drawings.

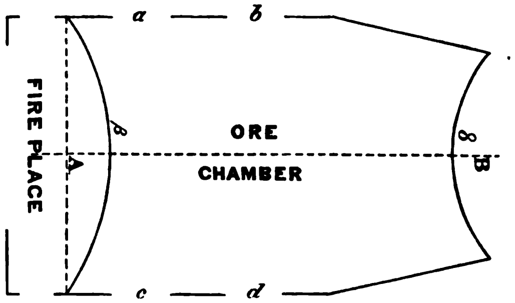
The fireplace, the ore-chamber, and three condensing-chambers are all contained in a single block of masonry, which I shall call the "furnace-block." After this, comes a second block containing a series of twelve large condensing-chambers, and immediately adjacent to this is a third one containing five more large chambers. All three of these blocks are built of brick throughout. The fumes from the furnace pass in succession through all twenty of these chambers, following successively the directions of the diagonals of the individual chambers, exactly as in the case of the Knoxville reduction works, a description of which will be found further on.

The mercury of course penetrates and saturates to a greater or less extent the walls of all these buildings, and in order to prevent the metal from percolating downwards through the foundations of the works into the ground beneath them, the furnace-block and all the condensing-chambers are built upon a series of small arches turned in brick, which support the whole. Beneath the intrados of each arch a floor of tiles is laid, sloping gently from either side toward the central or axial line of the arch, and thus forming a gutter along this line, the gutter so formed having also a gentle slope in the direction of its length, so that any mercury which finds its way on to this floor is discharged at the end of the arch into the gutters built here to receive it and conduct it to the kettles. These floors, after being laid with tiles, are all covered with a coating of cement, which is made as smooth and impervious as possible. Moreover, into the solid walls at the sides, and beneath the skew-backs of these arches, there are built sheet-iron plates, which are laid with a gentle slope towards the interior of the arches, so that any mercury which is percolating downward through the walls will be stopped by these plates and discharged upon the flooring and into the gutters beneath the arches. I do not think that the coating of cement beneath these arches is entirely impervious to mercury. But if it were so, and if the iron plates at the sides of the arches extended everywhere to the exterior of the buildings, it is evident that it would completely prevent the loss of mercury from this cause. As it is, this loss is insignificant in comparison with what it was in some of the earlier furnaces erected here.

The exterior dimensions of the furnace-block are forty-four feet in length by fifteen feet in width, and it is twenty-three feet eight inches high above the level of the ground, the foundation arches being built below the surface of the ground. Of the forty-four feet in length, the three attached condensing-chambers occupy fifteen feet eight inches, and there is then a passage-way about five feet long leading to them from the ore-chamber.

The horizontal section of the ore-chamber is of the form shown in the following sketch.

The line A B is longitudinal to the furnace-block, and the fireplace, which is at the end marked A, reaches entirely across transversely to the furnace-block and from the bottom of the ore-chamber to the top of the fire-wall; β is a section of the fire-wall about nine inches thick, built in the form of a segment of a vertical cylinder, and filled from top to bottom with "pigeon-holes" about four inches wide and five inches high, for the easy passage of the heated gases from the fireplace into the ore-chamber; δ is a perfectly similar "pigeon-wall" at the opposite or back end of the



ore-chamber, through which the fumes pass from the ore-chamber towards the right into the first of the three attached condensing-chambers. Beneath the portion of the block shown in the sketch, which contains the fireplace and ore-chamber, there is but a single foundation-arch, which runs longitudinally to the block, beneath the axial line A B. And the gutter of the floor beneath this arch slopes towards the front or fireplace end of the block marked A, and directly in front of this end of the block is the cast-iron kettle or pot, which serves to collect and hold, until it is weighed into the flasks, all the mercury which is produced by the furnace. Beneath the three attached condensing-chambers at the opposite end of the block, there are two foundation-arches, which are parallel to each other and to the one beneath the ore-chamber, but whose gutters slope in the opposite direction and discharge the mercury which finds its way to their floors into external gutters at the opposite end of the block.

The ore-chamber extends to the top of the furnace-block, where there is a large opening for charging the furnace. But the pigeon-walls do not extend so high as this. On the contrary, there is sprung across their tops, at each end of the ore-chamber, another horizontal arch (i. e. with horizontal axis), the height from the crowns of these arches at each end of the chamber to the top of the block being three feet. At the bottom of the ore-chamber, on either side, there are two holes or doors, about two feet square. marked *a*, *b*, *c*, *d*, in the sketch, for discharging the furnace. When the furnace is in operation these doors are closed by a brick wall luted with cement.

All the condensing-chambers are in the form of rectangular parallelopipedons, which are high but narrow, and whose horizontal length lies across, or at right angles with, the length of the block which they form; and each chamber extends entirely across the block.

In the second and third blocks, which contain the seventeen condensing-chambers, there is at each end of each chamber, at the bottom, an opening which, when the furnace is in operation, is closed with a sheet-iron door and luted. These openings serve to permit access to the interior of the chambers whenever it is necessary to clean them out, and also to admit the external air in order to cool off the chambers as rapidly as possible whenever the furnace is not in actual operation. The tops of the condensing-chambers are not covered with iron plates, as at the Knoxville Works, but are simply arched in brick. Their bottoms are floored with tiles with a smooth coating of cement. Furthermore, in the second and third blocks, these floors are highest in the middle of the chambers, and slope towards either end, so that a longitudinal section of the chamber-floor, transverse to the block, would resemble in appearance the roof of a house. This is done in order that the condensed mercury may flow out at each end of the chamber through a little pipe beneath the door into the external gutters, built also in brick and lined with cement, and which run parallel with the length of the block on either side from end to end, beneath and in front of the chamber doors, and which conduct the mercury to the iron pot already mentioned, whence it is weighed into the flasks.

The furnace-block itself, however, being considerably narrower than the blocks of condensing-chambers proper, the floors of the three attached condensing-chambers in this block slope only in one direction and each of these chambers has a door at one end only. From the last of the series of condensing-chambers, the vapors pass through a long inclined flue leading several hundred feet up the adjacent mountain-side, where a low chimney-stack discharges them into the air.

The dimensions which I noted of this furnace and its chambers are as follows: —

Internal length of ore-chamber on central line between pigeon-walls, eleven feet ten inches.

Internal length of ore-chamber from corner to corner, fourteen feet four inches.

Width of ore-chamber at fire-wall, and at angle of side walls, nine feet four inches.

Width of ore-chamber at back pigeon-wall, seven feet three inches.

From corner at fire-wall to angle in side walls, nine feet.

From angle in side walls to corner at back pigeon-wall, five feet four inches.

Height of ore-chamber to spring of arch over fire-wall, thirteen feet.

Height of ore-chamber to spring of arch over back pigeon-wall, fourteen feet.

Height to crowns of arches over pigeon-walls at either end, seventeen feet.

Total height of ore-chamber, twenty feet.

Thickness of side walls of ore-chamber where thinnest, i. e. opposite the widest portion of the ore-chamber itself, two feet ten inches.

Exterior height of the top of the ore-chamber above the adjacent ground, twenty-three feet eight inches.

Exterior height of the same, at the front end above the bottom of the gutter beneath the foundation-arch, twenty-nine feet two inches.

Height of spring, or skew-backs, of foundation-arch, above bottom of gutter at front end, sixteen inches.

Height of foundation-arch itself, two feet six inches.

Width of foundation-arch, five feet two inches.

Floor beneath foundation-arch slopes eight inches from sides to centre, and the gutter slopes six inches from rear to front.

The iron plates in the side walls of this arch are only two and a half feet wide, and therefore only just about cover the area beneath the ore-chamber itself, and do not reach out beneath the side walls of the chamber.

The opening at the top of the ore-chamber has the same general form as the horizontal section of the ore-chamber itself, except that the ends are straight instead of being arcs of circles. Its maximum width is the same as that of the ore-chamber itself, i, e. nine feet four inches. Its width at the opposite end, i. e. towards the back pigeon-wall, is eight feet. The length of the parallel portions of its sides is six feet three inches. The length of the converging portions is three feet, on either side.

External width of furnace-block, fifteen feet.

External length of furnace-block, including three attached condensing-chambers, forty-four feet.

Portion of this length occupied by condensing-chambers, fifteen feet eight inches. The average internal width of these chambers is about three feet nine inches. The thickness of the partition-walls between the chambers is nine inches.

The thickness of the outside walls of these chambers at the bottom in front is eighteen inches; but a little higher up it is twenty-two inches.

The second block, i. e. the one containing twelve condensing-chambers, measures from out to out, sixty feet in length, twenty-two feet in width, and twenty-four feet three inches in height above the bottoms of the doors at the mouths of the condensing-chambers, being twenty-nine feet three inches above the mouths of the gutters beneath the foundation-arches.

It should be mentioned that this block, as well as the third one (of five chambers), is built upon three parallel foundation-arches, which run longitudinally (i. e. transversely to the chambers themselves) from end to end of each block.

The thickness of the crowns of the arches at the tops of the condensing-chambers is nine inches, i. e. a single brick's length.

The outside walls of both these two blocks of condensing-chambers are everywhere thirteen inches thick, and the partition-walls between the adjacent chambers are nine inches thick.

The average internal width of the chambers themselves is therefore about four feet one and a half inches.

The rise of the floor of the chambers from the mouth to the centre is two feet.

Some of the dimensions last given belong only to the second block, which contains the twelve condensing-chambers. The five other chambers in the third block are of the same length and height as the preceding, but are somewhat narrower, the length of this block from out to out being but nineteen feet, while its width and height and the thickness of its walls are the same as the preceding. It appears, by calculation from the preceding, that the cubical contents of the ore-chamber of this furnace is in round numbers two thousand one hundred and fifty cubic feet, while the amount of condensing space is not far from thirty thousand five hundred cubic feet, or about fourteen cubic feet of condensing space to one of the ore-chamber. I may also note here that the average charge for this furnace from November, 1863, to December, 1866, as appears from the printed reports of the company, was about eighty-four and a quarter tons, adobes included, which makes the average cubic space occupied by each ton of ore in the chamber about twenty-five and a half cubic feet.

At the centre of each condensing-chamber a short brick arch springs from the partition-walls on either side, and arches directly across the chamber, in order to support the centres of the partition-walls. And the series of these stay-arches runs through the block from end to end along its central axis. The openings in the partition-walls for the passage of the fumes from one condensing-chamber to the other are three feet square. The grade of the external gutters along the sides of the block, below and in front of the mouths of the chambers, is about one in forty. The doors of the chambers are about two feet square. All these blocks of masonry are further strengthened and supported by vertical timbers placed against the outside of the walls, and held in place by numerous long iron tie-rods or bolts, which traverse the block completely from side to side and from end to end, being built into the solid walls.

The quantity of mercury which percolates through the walls and runs from beneath the foundation-arches varies, of course, with the quality of the ore in the furnace, and is sometimes large. The foreman of the Hacienda, however, informs me that not only is the absolute quantity of metal so obtained greater as the ore is richer, but that in the case of rich ore it is actually greater in proportion to the total product of the charge than it is with poorer ore. If this be correct, it is a curious fact, and one of which I do not know the cause.

Furnaces Nos. 1 and 2 stand side by side on the right bank of the creek. Furnace No. 1 has sixteen condensing-chambers, and from the last of these chambers the fumes pass first into the bottom of a brick tower, then out at its top and through a wooden flue perhaps fifty feet long into another very low brick tower, where they meet the fumes from furnace No. 2. The latter furnace has eighteen condensing-chambers. From the last of these chambers the fumes pass into the bottom of a brick tower, then out at its top, and into the top of another tower, where I suppose they descend and rise again, as they pass out at the top on the opposite side of the same tower, and through a wooden flue into the little tower where they meet the fumes from furnace No. 1, and whence the fumes of both furnaces pass on together through the long inclined flue and out at the stack on the hillside.

Furnaces No. 3, 4, 5, 6, and 7 are in a cluster on the left bank of the creek. Furnace No. 3 has three attached condensing-chambers, from the last of which the fumes pass into the first one of a block of eighteen chambers, in the sixth one of which they meet the fumes from furnace No. 4. The latter furnace has also three attached condensing-chambers, whence the vapors pass in succession through two separate blocks, the first one containing three chambers and the second one four, from the last of which the fumes pass into the sixth one of the block of eighteen chambers, where they meet the fumes from furnace No. 3. From thence the fumes from both these furnaces pass on together through the remaining twelve chambers of this block, and thence into a large wooden structure, which originally consisted of several separate chambers, but now of only one, the internal partitions having fallen away. From this structure they pass into a brick tower, and then out through the long flue.

Furnace No. 5 has three attached condensing-chambers, whence the fumes pass first into the top of a brick tower, where they descend, then pass under a road and enter the bottom of a second tower, where they rise again, and pass from thence into the first one of a block of five chambers, where they meet the fumes from furnace No. 7.

Furnace No. 7 has four attached condensing-chambers in the same block, from the last of which its fumes pass into the first of the block of five chambers, where they meet the fumes from furnace No. 5. The fumes from both these furnaces then pass on together through this block, and on leaving it pass successively through two large wooden blocks, the first of which originally consisted of four and the second of three separate chambers, though the internal partitions are now all broken down, so that each block consists in reality of but a single large chamber. From the last of these two wooden blocks the fumes pass first into a brick tower, where they descend, and then out through the long flue.

Furnace No. 7 differs in its construction from the others, inasmuch as the fireplace, instead of being at the opposite end of the block from the attached condensing-chambers, is in the middle of the block, between these chambers and the ore-chamber; and the fumes on issuing from the opposite side of the ore-chamber are compelled at once to descend and then pass back beneath the bottoms of the ore-chamber and the fireplace in order to reach the first attached condensing-chamber. This arrangement was intended, I believe, to effect a saving of fuel. But it appears to be a bad one, inasmuch as the circuitous route which the vapors are thus compelled to travel interferes with the draft of the furnace, while the position of the fireplace in the middle of the block has a tendency to heat the adjacent condensing-chambers to a higher degree than would otherwise be the case. The wooden condensing-chambers, also, do not appear to have answered their purpose very well, as they are not very durable, and the mercury penetrates them to a large extent. Furnaces Nos. 5 and 7 were of course intended to work together simultaneously, as in the other cases where the fumes from two separate furnaces pass together through a portion of the same series of condensers. But I am told that it is impracticable to work more than one of these two furnaces at a time, the draft not being strong enough for both. Furnace No. 6 is the only one on this side of the creek which has throughout its own separate set of condensing-chambers, into which the fumes from no other furnace pass.

Mr. Fiedler, the foreman of the Hacienda, is inclined to think that the ore-chambers of these furnaces are generally rather too long in proportion to their width, as there is sometimes difficulty in roasting completely the ore in the back and lower portions of the charge without heating the front and upper portion so highly as to cause incipient fusion. The tendency of the draft, of course, is to be strongest through the upper portion of the chamber. And therefore in charging the furnaces, they put, so far as practicable, the finer material in the upper portion of the chamber. But in addition to this it has also been found necessary, in some of the furnaces at least, to construct a special arrangement by which the direct draft through the upper portion of the chamber can be shut off and the vapors forced to traverse the lower portion, while at the same time a few small horizontal flues are built with the adobes through the lower portion of the charge.

All these furnaces work interruptedly; i. e. the ore-chamber is first charged to its full capacity, the doors at the bottom closed and luted, the opening at the top covered over and thoroughly luted with mud, and the fire then started. After the charge is completely reduced the fire is drawn, the doors opened to allow the air to circulate freely through the hot mass and cool it as fast as possible, the exhausted ore then drawn out at the bottom doors, and the furnace recharged.

An average of about one charge a week is burned in each furnace. One day the furnace is charged. The firing then continues for about ninety-six hours, i. e. four days; about a day is then allowed for cooling off, and the following day the charge is drawn. During the first twenty-four to thirty-six hours of the firing the heat is kept rather low, in order to thoroughly dry and gradually heat to a moderate degree the whole mass of the ore, and during the latter part of this period considerable quicksilver runs from the attached condensing-chambers in the same block. After this the heat is pushed to a higher degree, and the fire kept brisk and steady throughout the remainder of the firing, until the whole mass of ore in the chamber has been brought to a cherry-red heat. When this is accomplished the firing is done. During this portion of the time the attached condensing-chambers become heated too hot for the mercury to condense here, and the flow from them gradually stops entirely.

I will here note a point which I should have mentioned elsewhere, that the waste-heaps, i. e. the dumps, at the New Almaden Mine have long ere this been repeatedly and at last pretty thoroughly overhauled, and that at the present time there is no ore remaining in them, so far as known, which it will pay to sort out and reduce at present rates of expenses; or rather, since the comparatively recent rise of not far from fifty per cent in the price of quicksilver may perhaps modify this statement, I would say, which would pay any considerable profits at present rates, though there is undoubtedly a large quantity of ore containing from one to two per cent of metal which might yet be selected from those heaps. I am informed, however, that there was at one time in practice here a system by which the ore was reduced by contract at a fixed price per flask of quicksilver extracted. Under such circumstances, with a supply of rich ore in the mine, which (so far as the contractor was concerned) was unlimited, it became of course the interest of the contractor to extract as many flasks of quicksilver as possible within the limits of the duration of his contract, regardless of the question whether the reduction of the ore was anything like complete or not. A result of this performance was therefore, very naturally, that large quantities of ore were discharged from the furnaces and thrown among the furnace-tailings in a condition not much more than half reduced, and consequently in more recent years many thousands of dollars' worth of quicksilver have been obtained by sorting over these old furnace-tailings and picking out the unreduced portions of the ore. But this resource, too, has been pretty well exhausted for the present. There is said, however, to be a considerable quantity of this material still remaining in the mass which forms the planilla in front of and beneath the present reduction works and other buildings on the left bank of the creek. But this is not obtainable now without tearing up the whole mass of the planilla itself, which is needed for other purposes. Whenever, therefore, the New Almaden Mine shall be reduced to its old dumps and piles of furnace-tailings as a resource for quicksilver, which it is not now (nor do I think there is any certainty that it will be for at least a considerable time to come), its resources will be very small.

It will be noticed as a significant fact that the Day Tunnel — the lowest level in the mine — has been extended directly beneath some of the largest and richest labores which were ever found in this mine, and yet that it has failed to develop any important bodies of ore. But of course it does not follow with any certainty from this, that the mine may not elsewhere, and possibly even in the near vicinity of the actual drifs on this level itself, yet prove to be rich in depth. Indeed, for aught I know to the contrary, it might be perfectly possible to drive tunnels into this hill, and extend drifts from them in various directions, and run entirely around and above and below great masses of ore, and yet fail to find them; and then long years afterwards, perhaps, some more lucky exploration might happen to penetrate the right spot and develop ore to the value of hundreds of thousands if not of millions of dollars. Just so irregular as this does this whole mine appear to me to be.

From the published reports of the company it appears that, taking all the charges of ore which were burned from November, 1863, to December, 1866, the average weights of the charges for the different furnaces during that time were in round numbers as follows: —

Furnace No. 1,	37¼ tons.
" " 2,	37¾ "
" " 3,	40½ "
" " 4,	39¾ "
" " 5,	40¼ "
" " 6,	84¼ "
" " 7,	77½ "

The "ton" here used is 2,000 lbs. Av. But it should be noted that the weights of different charges in the same furnace vary largely with the character and quality of the ore. And, indeed, during these same three years, the amount of this variation for the different furnaces was nearly as follows: —

For Furnace No. 1,	12 tons.
" " " 2,	12 "
" " " 3,	15 "
" " " 4,	14 "
" " " 5,	13 "
" " " 6,	23 "
" " " 7,	12 "

There are four separate long inclined flues running up the hillsides from the works. One of these flues conducts away the fumes from furnaces Nos. 1 and 2, another from furnaces 3 and 4, a third from furnaces 5 and 7, and the fourth from furnace No. 6.

The flasks in which the quicksilver is sent to market are all of wrought-iron, welded. Into each flask are carefully weighed seventy-six and a half pounds of quicksilver; that quantity being about equivalent to seventy-five Spanish pounds, which is the recognized standard weight of a "flask of quicksilver" throughout the world.

Furnace No. 6, with its condensing apparatus, is said to have cost not far from $25,000. It is also stated that the present cost of reduction alone, exclusive of interest on capital invested in the furnaces, etc., is about fifty cents per carga. To burn a charge in furnace No. 6 generally requires not far from eighteen cords of good oak wood. The smaller furnaces generally consume twelve to thirteen cords at a charge. The remarkably small quantity of fuel consumed in the furnaces at the Redington Mine is undoubtedly due to the large quantities of sulphuret of iron contained in that ore.

I have been able to obtain very little information respecting the comparative quantities of ore and of waste rock extracted from the New Almaden Mine in different years; but from statements in the annual report of the company, dated

February, 1870, it appears that some record of this was kept during the years 1868 and 1869, and that in 1868, the proportion of ore to waste rock mined was nearly one to five and a half; while in 1869 it was approximately one to six and three quarters.

Accompanying these notes will be found a table of statistics showing the history of the production of this mine from 1850, down to December 31, 1870, as completely as I have been able to collect it. These statistics are collated and arranged from the various printed annual reports of the company, — a complete set of which has been kindly loaned me.

And I wish to express my obligations and sincere thanks to all the officers and the gentlemen connected with the management of the company and its mines, for the kindness with which they placed at my disposal every possible facility for the execution of my work.

The table of statistics here given* will explain itself with a single exception, and that is, the three Spanish terms "grueso," "granza," and "tierras" employed to designate the different kinds of ore.

By the term "grueso" is meant the best, or first-class, ore in large lumps, generally eight inches or more in diameter. A great portion of this ore has consisted of nearly pure cinnabar with very little admixture of waste rock.† The term "granza" is employed to designate the balance of the ore in fragments of various sizes, from lumps not more than eight inches in diameter down to the finest material which does not pass through the screens which are used on the planillas. The "granza," moreover, is always of much poorer average quality than the "grueso." The "tierras" are the earthy matter and finer ore-siftings which pass the screens, and which contain a considerable quantity of cinnabar distributed through them in fine particles. These "tierras," as already stated, are mixed with clay and made into adobes, in which condition they are burned in the furnaces with the rest of the ore.

The table exhibits some interesting facts. It appears from it that the total yield of the New Almaden alone, up to the 31st of December, 1870, was 525,066 flasks, = 40,167,549 lbs., of quicksilver, to which if we add the 10,571 flasks produced by the Enriquita (which has now been idle for a number of years) we obtain a grand total from the mines now owned by this company alone of 535,637 flasks. What the owners of the mines themselves have actually received for this amount of quicksilver I do not know, and it might be impossible to ascertain. But during these twenty years it has probably sold in the markets of the world for not less than twenty-five millions of dollars; while, at the present price, its market value would be considerably over thirty millions.

It will be noticed farther that while there was a great and rapid increase during a period of these years in the quantities of ore reduced, the average monthly product did not increase in anything like a corresponding ratio; but there has been a great and almost steady decrease in the average percentage yield of the ore from the commencement to the present time. The largest quantity ever produced by the mine in a single month, so far as I can learn, was in July, 1864, when the product was 4,801 flasks. The smallest for many years was in July, 1870, when it fell to 731. It is now about 1,500. The largest quantity ever produced in a single year was in 1865, — 47,194 flasks. Further comment upon the table is probably unnecessary.

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* This table will be found appended to Mr. Goodyear's Report, some pages further on.

† "Grueso" signifies *fat*; "granza" is a word used by the Spanish both for *chaff* and *dross*; "tierras" is equivalent to *earth* or earthy portions of the ore. — J. D. W.

How to account satisfactorily in all respects for the formation of the New Almaden and adjacent mines, and for the curiously irregular positions which the larger bodies of ore have occupied, I freely confess I do not know. But if I were to state the general theory which seems most plausible to me now, I should say that they seem to have been a result of solfataric action, the mercurial vapors rising through irregular crevices from below, and becoming condensed in caverns which may either have pre-existed in the somewhat calcareous rock, or possibly have been simultaneously formed to a considerable extent by the leaching and carrying away of the substance of the rock itself, while the rocks all around in the vicinity of the masses of ore appear to have been greatly cracked and shattered, and thus to have become filled to a greater or less extent with irregular seams and threads of cinnabar which run in every possible direction. I certainly do not think that there is anything volcanic about it. Nor, so far as I could see, does there appear to be anything like a regular vein, or, indeed, properly speaking, a "vein" of any kind, within the limits of any depth to which the workings have yet extended.

Throughout the whole history of the mine the only guide to new and undiscovered bodies of ore has been the little "hilos," or threads of cinnabar, which have been followed here and there through the country rock. I know of no reason why there may not be enormous masses of cinnabar still existing in almost any portion of this hill, where the underground works of the mine have not already been actually carried. But at the same time I know of no definite indications of their existence, nor of any better means of finding them if they do exist, than by following the little seams, as has been done heretofore; — unless, indeed, the cost of boring could be reduced to so low a figure that holes might be sunk to great depths all over the hill, so close together that no large bodies of ore could escape them.

GUADALUPE MINE.

The Guadalupe Mine is situated about four miles northwest of the crest of the Mine Hill, and near the sharp bend of Los Capitancillos Creek. The Mine Hill ridge is much lower here than it is at the New Almaden Mine, and the Guadalupe Mine is in the southwestern slope of the ridge, near its foot. A portion of the mine also extends to the west, beneath the bed of Los Capitancillos Creek itself. There has been a good deal of "coyote-work" done at the Guadalupe Mine in the shape of open cuts in the hill-side. The surface at this point is generally covered with a heavy bed of earthy matter which is deeply stained with oxide of iron, and through which the cuts have been opened to the rock beneath. Lower down the hill, and nearer the creek, a couple of tunnels have been driven for short distances into the hill, and through these tunnels considerable ore has been taken out. The exhausted chambers here are some of them of considerable size, and are scattered through a hundred feet or more of ground, in a northwest and southeast direction, with a pretty steep northeasterly pitch. It is said that a considerable portion of the ore which came from here was rich, running as high as from twenty to twenty-five per cent.

Below here, in the bottom of the cañon, but on the right or northeast bank of the creek, an inclined shaft has been sunk, going down in a southwesterly direction some four hundred and thirty or four hundred and forty feet with a pitch of 46° or 47°. This shaft is now filled with water, and the workings at the bottom are of course inaccessible. But it is said that from the foot of this shaft one drift was run about six hundred feet towards the southeast, while another one was carried to about an equal distance in a westerly or northwesterly direction. A short distance southeast of the mouth of the inclined shaft there was a vertical one, said to have been one hundred and seventeen feet deep. A little farther still to the southeast was another vertical shaft, said to have been two hundred and seven feet deep. Both of these shafts were connected with the workings at the foot of the incline, and both are now in ruins.

It is stated that considerable rich ore was taken from these lower workings, and also that there was still a pretty large quantity of very fair ore in sight at the time the work here was discontinued, the stoppage having been occasioned by the influx of water, which became too great for the capacity of the pump to handle. I do not know how close to the facts these statements may be, but it seems hardly probable that any very large quantity of rich ore should have been proven to exist, and then left untouched in the bottom of this mine for so long a time (some three or four years), as it has been since work here was stopped; because, if the ore were rich, it would not take a very large quantity of it to pay for all the new pumps and machines which might be required to free the mine from water for a considerable time to come. The mining operations now carried on here are very small, only a few Mexicans being employed in picking around the open cuts, etc., in the sides of the hill. The ore obtained is small in quantity and of low grade, and the average monthly yield is probably not over thirty flasks.

There are at this mine two small furnaces, built of brick, upon the same general plan as those at New Almaden. The capacity of one of these furnaces is said to be about seven or eight tons, and that of the other in the vicinity of twenty-five tons of ore. The larger furnace is not now used at all. I am told that the external walls of this furnace and also of its condensing-chambers were built double, a vacant space of dead air being enclosed from top to bottom between the exterior and interior portions of the wall. And I am told that a similar construction has been employed to some extent in a few furnaces elsewhere. But I am completely at a loss to understand what was the object or what should have suggested the idea of constructing in this style the walls of condensing-chambers. It appears to me to be an admirable expedient, so far as it goes, for retaining the heat within the chambers and preventing the mercury from condensing there.

ENRIQUITA MINE.

The Enriquita Mine is not far from half-way between the Guadalupe and the New Almaden, and it is also in the southwestern slope of the ridge. Reduction works similar to those at New Almaden, but on a smaller scale, were also built here on Los Capitancillos Creek just below the mine, and all the ore produced by the Enriquita was here reduced. No work has been done here now, however, for a number of years, and the mine is said to be badly caved. I did not visit it. It is stated that a large proportion of the ore which came from here was very rich; but that it was all extracted and nothing of any value was left in sight when the work was stopped.

I should have mentioned that at the New Almaden Hacienda the lowest level portion of the railroad, already mentioned as being nineteen hundred and thirty feet long, is somewhat higher than the roofs of the sheds which cover the reduction works. From here the ore is shot through wooden shoots some twenty-five or thirty feet lower, to another track, which leads directly across the top of furnace No. 6 (which it serves to charge) and then on a wooden trestle across the creek to furnaces Nos. 1 and 2.

SAN JUAN BAUTISTA MINE.

The San Juan Bautista Mine is in the northeastern portion of an isolated range or cluster of hills bearing the same name in the valley about four miles southeast of San José. The higher portions of these hills southwest of the mine, so far as I saw them, seem to consist chiefly of serpentine, which is generally, however, very impure, and is probably a metamorphic form of sandstone. Most of the lower slopes of these hills near the mine are covered with a deep black soil, beneath which lies the quicksilver rock.

There are more or less underground workings here, extending from nearly the level of the plain up to a height of something over two hundred feet in the hill. The lowest tunnel runs into the hill in a direction S. 25° or 30° E. for a distance, as I am told, of about nine hundred feet. The rocks here seem to strike nearly east and west magnetic and dip southerly, and the labores in the mine generally have nearly the same trend. The upper portion of the hill has been worked for a length of some three hundred feet, and to the depth of between one hundred and two hundred feet, in irregular chambers, which have sometimes been fifteen or twenty feet wide. Some of the ore taken from here is said to have been very rich, but the greater portion of it was of low grade.

The rock near the surface of the hill bears much resemblance to that of New Almaden, but is softer, and seems to be more decomposed. It contains some lime, but no great quantity. On going deeper it gradually changes its character, becoming harder and more silicious, and at the same time poorer in cinnabar. In one place, in the lower part of the mine, I saw a large mass of nearly pure quartz, whose character seemed to be about midway between that of ordinary quartz and of chalcedony. There were also brecciated pebbles, cemented together by silica. Most of the rock in the lower portion of the mine is of a dark gray color, very hard and silicious, and granular-crystalline in texture. There is no ore now in sight in these older workings. The present workings are east of the old ones, and nearer the reduction works. Here they had, at the time of my visit, a "labor" of tolerably good ore, which seemed to strike about N. 60° E. magnetic and to dip in a southerly or southeasterly direction.

They have a single furnace here, built after the same general plan as those at New Almaden, and whose capacity is stated to be about twenty tons. The fumes pass first into a tower with two condensing-chambers, and thence through a series of eight more chambers, all built of ordinary brick. The furnace rests on one arch, the condensers on three. Iron plates are built into the sides of these arches. Some of the ore worked here is said to yield as high as eight per cent, but the average is less. The product is from thirty to forty flasks per month.

NEW IDRIA MINE.

The New Idria Hacienda is situated in the bottom of the cañon of the San Carlos Creek, and is said to be at an elevation of about twenty-five hundred feet above the sea. It is stated in Vol. I., page 57, that it is "just within the borders of the metamorphic." I should be more inclined to say that the Hacienda itself is just outside these borders, while the mine is just within them. The line of demarcation between the altered and unaltered rocks here may perhaps be a little indistinct, but I should be inclined to draw it between the Hacienda and the mine. Certain it is that the rocks in the immediate vicinity of the Hacienda, so far as I saw them, are comparatively very little altered. The mine is situated in a spur of the mountain southeast of the Hacienda, at an elevation of from one thousand to fifteen hundred feet above it, and at a distance from it by the road which I judge to be about a mile. The direction of the axis of this spur is somewhat to the west of north, and the mine is in the western or southwestern side of the spur, not much below its crest. It is on the southwest side of the San Carlos Creek. This creek, which heads at the divide one or two miles southeast of the summit of the San Carlos Peak, runs first for several miles to a point a little beyond the Aurora Mine, in a direction not far from west-northwest. It then makes a sharp bend, runs northerly for some three quarters of a mile or a mile, then nearly west to the Hacienda, below which, for several miles, its general course is nearly north magnetic.

The "croppings" at the New Idria Mine project from the side of the spur in the form of a ragged rocky ridge several hundreds of feet in length, and having a nearly east and west course. But there does not appear to be anything like a vein here, any more than at New Almaden, or at any of the other quicksilver mines in the State. Furthermore, there have never been at New Idria anything like the great rich chambers of New Almaden. The cinnabar is more generally distributed through the rock, and though some of the labores are large enough, they have never been so rich as many of those at New Almaden, and the ore has always been of comparatively a low grade.

The rocks in the New Idria Mine may be divided into two classes, viz. the ore-bearing rock and the barren ground. The former (which here, as well as at New Almaden, is called the "vein-rock" by the miners, wherever they find it) is rather a dark-colored grayish clay-rock, heavy-bedded, — so much so that it is rare that any bedding can be traced in it, — more or less fissured, and generally considerably metamorphosed, silicious, and often very hard. It contains almost everywhere a notable though not very great quantity of iron pyrites distributed through it in fine grains and occasional seams. The cinnabar occurs in this rock, not in large pure masses, but traversing it in every direction in thin seams, which are generally granular or massive and rarely distinctly crystalline in their texture. The quantity of iron which is generally distributed throughout this rock is sufficient to impart to the burned ore which constitutes the furnace-tailings a brick-red color which is very deep and dark, and which indeed is closely suggestive of the color of hematite powder itself. Very little carbonate of lime is to be seen either in or about the mine. There are also, of course, great quantities of this rock which contain very little cinnabar and do not pay for working. The other class of rock, which I have called the "barren ground," and in which no valuable quantity of cinnabar has ever yet been found here, is called by the miners "the wall" wherever it is met with; the local name for most of it is "soap-rock." It is a dark-colored, soft, clay-rock filled with slickensides, and apparently not very much metamorphosed, though it also contains occasionally more or less iron pyrites and sometimes little streaks of cinnabar. There is very little if any serpentine in the mine itself, though the quantities of it close at hand, in the country to the south and southeast, are perfectly enormous.

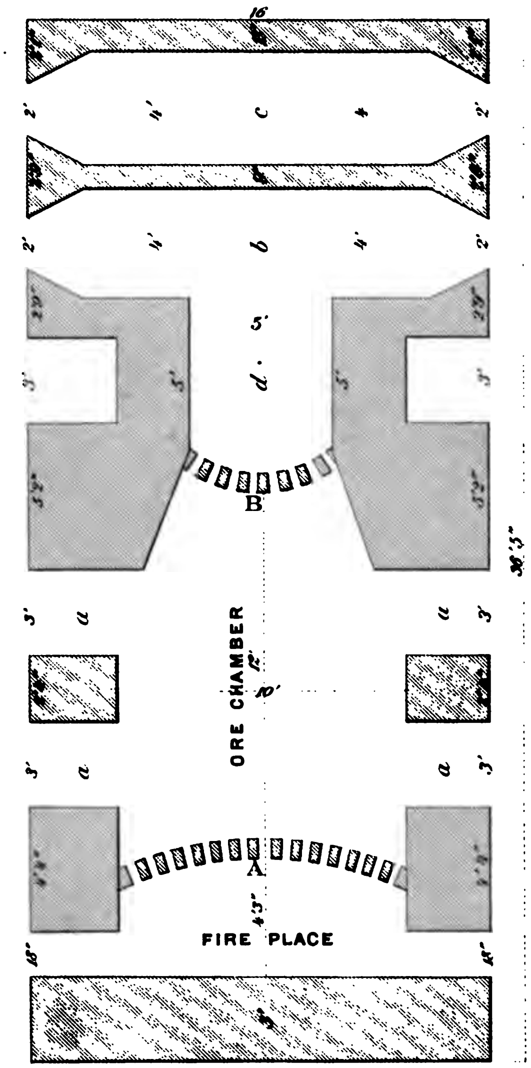
I did not consider it worth while to attempt a description of particular labores in this mine, and have therefore made only general notes. And I may remark here that the individual labores are exceedingly irregular both in form and position, and that I was unable to detect any definite system whatever in the distribution of the ore in the mine.

The chief levels in this mine are the following: —

Lower Tunnel	0 feet.
Myers Tunnel	200 "
Sleeman Tunnel	300 "
East Drift	380 "
New Hope Drift	550 "

The figures here given are the heights of the various levels in feet above the level of the Lower Tunnel.

The Lower Tunnel runs in, straight at first, for a distance of about three hundred and eighty feet in a direction about S. 48° 15′ E. magnetic (the variation of the needle being about 17° E. here), then some four hundred and fifty feet S. 15° to 18° E., then about five hundred feet a little south of east, then some two hundred and eighty feet, in a direction not far from N. 25° W., the end of this last portion of it being nearly beneath the centre of the main workings of the mine. The Myers Tunnel starts in at a point on the west (or southwest) of the second portion of the Lower Tunnel, and runs first for some distance southeasterly, then easterly,



Horizontal Section of Furnace Block No. 3.

NEW IDRIA, California.

Scale $\frac{1}{80}$.

crossing the line of the Lower Tunnel, then northeasterly into the main body of the workings of the mine, which it then traverses in all directions with its various forks and branches. The Sleeman Tunnel runs first about two hundred and thirty-five feet in a direction S. 33° 45′ E. magnetic, and then forks into three branches, one of which runs nearly east some four hundred and fifty feet, and another one runs southwesterly some two hundred feet, while the third, or middle one, curves through the country in a general southeasterly direction to points some six or seven hundred feet farther southeast.

The chief workings of the mine lie around and just southeast of where the Sleeman Tunnel forks, and within a circle of some four or five hundred feet in diameter. The greater portion of the quicksilver hitherto taken from this mine has come from between the Myers Level and the Sleeman Tunnel, and the remainder has come mostly from above the latter level, no large quantity of ore having ever yet been found below the level of the Myers Tunnel.

In the Lower Tunnel the stratification was seen in various places, and wherever noticed the strike was northwesterly and the dip northeasterly.

There are now at the New Idria Hacienda three furnaces, called respectively Nos. 1, 2, and 3, and a fourth one is in process of construction, and will be finished in a few weeks.

Furnace No. 1 is estimated to contain on the average forty tons of ore; furnace No. 2, to contain forty-five tons; and furnace No. 3, to contain fifty tons.

The annexed sketch (Plate E), drawn to a scale of $\frac{1}{80}$, exhibits a plan, or horizontal section, of furnace-block No. 3, taken just above the floor of the ore-chamber. The actual dimensions are marked on the sketch in feet and inches. In this sketch *a a a a* are the openings or doors on either side at the bottom of the ore-chamber. A is the pigeon-hole fire-wall, and B is the pigeon-wall at the opposite or back end of the ore-chamber. *d* is the passage-way leading from the ore-chamber into the first condensing-chamber *b*, whence the vapors pass into the second one *c*. These two attached condensing-chambers, built in the same block with the furnace itself, rise in the form of a tower to a considerably greater height than the top of the rest of the block. From the second of these two chambers the fumes pass to the block of condensing-chambers proper.

The condensing-chambers at New Idria are in general considerably higher than those which I have seen elsewhere, being about thirty feet high. The exterior dimensions of this block are twenty-three feet eleven inches by twenty-two feet eleven inches. Through the middle of it there runs a longitudinal partition-wall which is continuous without any openings through it from top to bottom and from end to end, except a single opening at one end of the block. The block itself is thus divided into two series of chambers, one on each side of the central partition-wall. In each series there are seven chambers, making fourteen in the entire block. The fumes, on entering this block from the furnace, pass first successively through the entire series on one side of the partition-wall, then cross over and travel backward through the other series, and finally leave the block at the same end at which they entered it. A result of this arrangement, of course, is that the last chamber in the block through which the fumes pass, and which should be the coolest one of all, is immediately adjacent to the first one which they enter, which is the hottest of all. The ore-chamber of furnace No. 3, which is represented on the plate, is stated to contain twelve hundred and eighty-one cubic feet; and, its capacity being estimated at fifty tons, it appears that each ton of ore occupies in the furnace about twenty-five and a half cubic feet of space, or very nearly the same as in furnace No. 6 at New Almaden. All the ore is hauled from the mine to the reduction works in wagons drawn by mules, at a cost of probably not less than seventy-five cents per ton.

Wood costs here from $ 6.00 to $ 6.50 per cord, and the three furnaces consume about twenty-eight cords per week, a single charge of ore being burned in each furnace in the same time. The quantity of wood required here, therefore, to burn a given quantity of ore, it will be seen, is notably less than is the case at New Almaden, and the difference is doubtless due, in part at least, to the quantity of iron pyrites which exists in the New Idria ore. The same criticism has been made upon the ore-chambers of the furnaces here as at New Almaden. It is thought they are too long in proportion to their width.

Furnaces Nos. 1 and 2 were built in 1866, and furnace No. 3 in 1867, the older furnaces having been all pulled down. But though the present furnaces have only been standing some four or five years, the walls of the condensing-chambers are generally in poor condition, and portions of them are in a very bad state indeed, being warped and sprung in every direction. This condition of the walls is undoubtedly due in part, at least, to want of sufficient tying with iron rods when the walls were built. But aside from this, there appears to be something in the furnace-vapors here, or else in the character of the material used in the construction of the condensing-chambers, which causes slow disintegration in the bricks when exposed to the fumes evolved in the reduction of the ore. The walls appear to become gradually penetrated to a considerable extent with some kind of efflorescent salts, and the exterior of the bricks exfoliates in thin scales, while here and there the salts themselves form whitish spots upon the exterior of the walls. I do not know precisely what the nature of these salts is. But the matter is one which is well worthy of a little investigation, as it might very possibly prove that the difficulty is one which can be avoided in future building. Some of the walls which are at present in the worst condition belong to condensing-chambers which are among those farthest removed from the furnaces.

But aside and entirely distinct from the efflorescent substances referred to above, there is another class of salts which accumulate in considerable quantities in the form of incrustations on the interior walls of the first two or three condensing-chambers nearest the furnace. The surface of these incrustations has generally the appearance of moss-like aggregations; but where they accumulate, as they sometimes do, to the thickness of several inches, the under portion of the crust adjacent to the wall is more compact, and its fracture sometimes exhibits an enamel-like appearance. This crust, when free from soot or dirt, is snow-white in color, and exceedingly heavy. But on being moistened with a drop of water it instantly changes its color to a bright, deep, and permanent lemon-yellow. I was told that some chemist who has examined it called it simply "subsulphate of mercury." But I am more inclined to believe that in the condition in which it exists in the chambers the crust consists chiefly of the simple sulphate of the protoxide, which on being treated with water is decomposed into a soluble acid salt and an insoluble yellow basic one, which is analogous to if not identical with the so-called "turpeth-mineral," which is a tribasic sulphate of mercury. On account of the large quantity of these incrustations, as well as of the matter which slowly accumulates in the other chambers, it becomes necessary to thoroughly scrape and clean the walls of all the condensing-chambers about once every six months. And at such times there is obtained, as I am told, from forty to sixty tons of material, consisting of dust and dirt of various kinds, mingled with a very large percentage of these rich mercurial salts.

It is a curious fact, if I am correctly informed, in connection with these sulphates, that, although their great specific gravity should at once have suggested the probability of their containing a large amount of mercury, yet a considerable time elapsed before it was actually ascertained what they were, and the mercury extracted from them; and it is said that many thousands of dollars' worth of them were thrown into the dump-heaps with the furnace-tailings, and covered up in places where they are not now accessible. Meantime a few experiments were tried by mixing them simply with clay and making them into adobes and then burning them in the furnaces in the ordinary way. The natural result of this experiment with oxidized salts was nothing, of course; and they were thrown away. A portion of them, however, was at last submitted to a chemist, who suggested the propriety of simply mixing intimately with the clay, in making adobes out of this material, a certain proportion of quick-lime and a quantity of powdered charcoal. This was tried with a result which, to those who first made the experiment, was probably slightly suggestive of magic. The oxidized salts were completely reduced, and all the mercury extracted. All of these salts are now treated in that way, and it takes but a small number of these "black adobes" to make a very perceptible difference in the yield of any furnace-charge in which they are employed.

It would be interesting to know the exact cause of the formation of so much sulphate of mercury in these chambers at New Idria, since I do not know that there is anything of the kind at New Almaden; nor did I hear anything of it even at the Redington Mine, where the quantity of sulphur in the ore is far greater than it is at New Idria. It has been supposed, and very possibly it may be the fact (though I do not know that it is at all certain), that the formation of these salts is due in some way to the almost entire absence of carbonate of lime in the New Idria ore. It is also stated that the quantity of these salts which collect in the chambers is greater in summer than in winter, — being greater in July and August, the two hottest months, than at any other time in the year. I do not know how to account for this last statement. It certainly seems difficult to suppose that the variations in external temperature alone (which may range perhaps through 90° F. at different seasons of the year) could affect the interior of these hot brick chambers, when the furnace is in operation, to such an extent as to influence very perceptibly any chemical operations going on there. Furthermore, if the formation of these salts were a matter which depended to any considerable extent upon variations of comparatively a few degrees in the temperature of the chambers, then it would only require careful attention, with the consumption of comparatively a very few sticks of wood, more or less, to greatly lessen, if not entirely prevent, their formation. I think, therefore, that it depends on other causes. I do not know, however, of any special difference which exists between the condition of the ore-charges and the interior of the chambers in the summer and their condition in the winter, excepting the difference due to variations in the quantity of moisture contained both in the ore and in the fuel, which is undoubtedly on the average very perceptibly greater throughout the winter than it is in the summer.

There were formerly at New Idria five small furnaces, whose capacity is said to have been about eight tons each. These have been pulled down, and the ground beneath where they stood has recently been dug up and found to be full of quicksilver to a considerable depth. In one place they went down about fifty feet, and found quicksilver all the way, though its quantity gradually diminished from the surface downwards, and at the bottom there was too little to pay for going farther. At the time of my visit there was one excavation here which I judged was eighteen or twenty feet deep, and the ground was filled with globules of liquid mercury all the way.

It is the opinion of the superintendents here, that these small furnaces were better in some respects than the present ones. It used to cost more to reduce a ton of ore in the smaller furnaces, but it is thought that they saved more quicksilver. I was told that Mr. Brodie, an engineer, now deceased, who was formerly employed here, once made a careful comparison between the smaller and the larger furnaces, and came to the conclusion that the former gave a product from the same ore greater by four or five per cent than the newer and larger furnaces; but that he assigned no definite cause for the fact. The mercury is extracted from the earth beneath where the old furnaces stood by sluicing it with water, and considerable metal is thus obtained.

In the construction of furnace-block No. 3, there were employed 158,130 brick.

All through the ragged rocky ridge which forms the outcrop of the ore-bearing rock at the New Idria Mine, there are more or less numerous seams and streaks of cinnabar, and it is probable that a good deal of this rock near the surface, although poor, may yet pay to extract and work. The quantity of ore now in sight in the mine which, though of low grade, is yet sufficiently rich to pay for working, is pretty large. Furthermore, they have never sorted the ore very closely to the lowest paying limit here, and the great dump-piles, which, at a rough guess, I should say might contain in the aggregate from 200,000 to 250,000 tons of rock, have never yet been overhauled; in these piles of rock there are many thousands of tons of low-grade ore, which it will yet pay to sort over, pick out, and reduce.

The various classes of ore, and the names employed to designate them, and also the mode of charging the furnaces at New Idria, all vary somewhat from those at New Almaden. At New Idria the coarser, i. e. the lump, ore is divided into three different classes, depending simply on the size of the pieces, and designated respectively "Number one," "Number two," and "Number three" ore. "Number one ore" consists of the largest pieces, varying from about five to one hundred and fifty pounds or more in weight; "Number two ore" consists of pieces ranging from about one pound to five in weight; and "Number three" consists of pieces weighing from about half an ounce to a pound. The finer screened ore is called "granza," its fragments varying from about half an ounce in weight down to the size of a small pea or a grain of wheat. The still finer ore-matter constitutes the "tierras," which are made into "adobes."

More care is observed in charging the furnaces at New Idria than at New Almaden. For instance, on the morning of April 14, I watched the latter portion of the operation of charging the ore-chamber of furnace No. 1 at New Idria, and in this case, after building up a wall of adobes in front of the doors or side-openings on either side at the bottom of the ore-chamber, and also in front of the pigeon-walls at either end from top to bottom of the chamber, the remainder of the ore was charged in five separate horizontal courses, of which each course also consisted of five distinct layers. The lowest layer in each course consisted of adobes. Over these was then spread a layer of "number one" (i. e. the coarsest) ore. The third layer consisted of "number two ore," the fourth one of "number three," and the fifth of "granza." On the top of the last came the next layer of adobes, constituting the lowest layer of the next course. The height of the lowest layer in each course was the thickness of two adobes. The adobes were laid flat and end to end in parallel lines, extending from one end of the chamber to the other. Between the lines of adobes were left parallel spaces or channels, which being covered over formed a series of horizontal flues extending through the length of the chamber. In the lowest course in the bottom of the chamber these channels or flues were made six inches or more in width, and these were covered over with adobes laid crosswise upon them before the "number one ore" was spread over them. In each successive course, however, these flues were made narrower and narrower, till in the upper course, nearest the top of the chamber, they were only left some two inches wide. When the upper course was completed and the last layer of "granza" spread over its top, a covering of tiles was laid over all; the cracks between these tiles were then thoroughly filled or grouted with a semi-liquid mud, and then covered over with a layer of mixed sand and ashes several inches thick, which completed the work of charging the furnace. The fire was then at once started on the grate below. For the first twenty-four to thirty-six hours of the firing, according to the quantity of moisture in the ore, the fire is kept comparatively low, and the heat is afterwards raised to a higher degree, as at New Almaden.

So far as the amount of production, the quantity of ore reduced, the percentage yield of the ore, etc., etc., are concerned, I have been able to obtain no statistics with reference to the New Idria Mine. On these points, therefore, I can only present my own estimates. With reference to the amount of quicksilver produced, the fact may be noted that for two years, from April 1, 1868, to April 1, 1870, the production of this mine was limited by contract to ten thousand flasks per annum. It is my belief that during this period the actual production was kept pretty nearly up to the contract limit. I also think that for some time preceding the 1st of April, 1868, the production did not fall much short of the same figures, and that since the

1st of April, 1870, it has probably little if at all exceeded them. The best estimate which I can make is to assume that for a period of four years ending December 31, 1870, the average annual production of the mine was ten thousand flasks, and that its total production prior to that period had been about twenty thousand flasks, thus making the total estimated production of the mine up to January 1, 1871, about sixty thousand flasks.

The percentage yield of the ore has probably ranged all the way from three or four to ten per cent. But from all that I saw while at the mines, I believe that the present average yield is in the near vicinity of five or six per cent. These figures, however, are simply estimates.

SAN CARLOS AND AURORA MINES.

The San Carlos Mine is situated at the summit of the peak of the same name. Between this and the New Idria Mine there is a very great quantity of soft and easily disintegrating serpentine rock, which is everywhere filled with little white seams that form a perfect network, running in all directions through it; and the high ridge immediately southwest of the San Carlos Creek, which forms for several miles the divide between this creek and the waters of the San Benito, consists chiefly of the same material. The Aurora Mine, in the bottom of the cañon on the southwest bank of the San Carlos Creek, is in what appears to be an isolated mass of rock, which is very silicious, ferruginous, and much honeycombed, looking like a silicious gossan. The surrounding adjacent rock is chiefly serpentine. This mine once furnished some good ore. But its quantity was not very large, and nothing has been done here now for several years.

At the very summit of the San Carlos Peak the rock is chiefly a partially metamorphosed, silicious, and ferruginous sandstone, often more or less cavernous. The workings of the San Carlos Mine are close to the summit of the peak, and extend entirely around its western side from south to north. These workings are now chiefly in the form of open cuts, and irregular as anything of the kind can possibly be.

By far the greater portion of the ore which now comes from here is in the shape of "tierras," the mine not affording at present over about fifty cargas per month of ore in lumps. The tierras come chiefly from a soft, somewhat metamorphosed clay rock, which is impregnated in places with cinnabar, and is also mingled here and there with more or less sandstone, in the distribution of which there seems to be no regularity whatever. Nearly all the material mined here now crumbles to a mass of earth. This earth is first packed by donkeys down to the San Carlos Creek, where it is concentrated by washing, after which the tierras so obtained are hauled to the New Idria Hacienda.

There is some quartz about the peak in the shape of seams, etc., and sometimes cinnabar follows these streaks of quartz. There is very little lime to be seen here. Portions of the sandstone are very hard, and there is some jaspery rock. No regularity whatever in the distribution of the cinnabar could be observed. The miners here are paid $ 3.50 per carga for the concentrated tierras which they obtain. It is stated that in the past there has been one, and only one, large body of rich ore found at the San Carlos Mine, which formed what was called the Tarantula labor. The ore from this deposit was obtained in large, rich, compact lumps. But it finally ran out altogether, and no more has since been found.

On the northwest side of the mountain, and at a depth, as I should judge, of some three or four hundred feet below the workings of the mine, is the mouth of a tunnel which was driven in southeasterly for several hundred feet to a point beneath the upper workings. It is said, however, that no cinnabar was found in this tunnel, but only a soft, bluish clay-rock, similar to that called "soap-rock" in the New Idria Mine.

PICACHO MINE.

The Picacho Mine is situated near the summit of the peak of that name, about five miles south of New Idria. The whole region around here and to the south, about the Picacho and Monterey Mines, is commonly called at New Idria a "magnesia country," and the name is a good one. The quantity of serpentine here is enormous, constituting probably more than four fifths of the whole mass of the mountains over an area of many square miles. Even where the rock is not serpentine it seems in general to be largely magnesian. The serpentine itself is generally impure, soft, very friable, and easily disintegrated, and the steep sides of the mountains, instead of exhibiting rocky outcrops, are generally covered with a smooth and barren soil of this disintegrated serpentine. No grass grows here, there are few bushes, even the pines are scattered and thin, and the mountains have a peculiarly naked and barren look. There are occasional outcrops, however, of a very different kind of rock. And the various quicksilver claims on which more or less work has been done about here, occur mostly in a very silicious rock, whose outcrop is generally rough, cavernous, and deeply stained with oxide of iron, as at the Aurora Mine.

At the Picacho I saw more indications of reduction works than I did of a mine, though it should be noted that I had no one with me who was familiar with the ground, and but little time to spend in looking about. I was told that some two or three hundred tons of ore have been extracted and reduced at this mine. A nice little furnace, whose capacity I judged at from twelve to fifteen tons, with condensing-chambers, etc., was built here, on the plan of those at New Idria and New Almaden. Its present appearance shows, however, that it has been little used. Besides this furnace there are still standing here the remnants of another apparatus erected by Mr. John Roach of San Francisco, and patented by him and Coult, April 17 and July 17, 1866. This apparatus consists, first, of a "furnace" in the form of a vertical cylinder of rolled iron lined with fire-brick; second, of a rectangular prismatic sheet-iron chamber with a vertical partition dividing it into two compartments, the fumes from the furnace entering one compartment at the top, then descending to the bottom, then rising again through the other compartment, and passing out at the top on the opposite side; third, of a large rectangular wooden vat about twenty-five feet long and eight or ten feet wide, and two feet deep at one end and five feet deep at the other, the top being horizontal. This vat has transverse vertical board partitions extending downward some eighteen inches from the top. The whole vat appears to have been closely covered over with a board top, and then to have been filled with water to the height of an inch or two above the bottoms of the transverse partitions, thus forming a series of little compartments separated from each other by the partitions and closed by the water at the bottom. It seems to have been the intention by means of a blower or other arrangement to exhaust the air from the end of this apparatus, thus producing a draft in the furnace and compelling the fumes to traverse in succession the little compartments in the top of the vat by passing through the water beneath the board partitions. The general idea is the same as in the little works which I found Mr. Roach engaged in erecting last fall at the Reed Mine in Lake County, though the details of construction are very different. There certainly have been some experiments tried with this thing, for all the grooves and crevices in the boards are yet filled with globules of quicksilver, but I do not know whether ore enough was ever worked to give it really a fair trial. I have serious doubts, however, of the economical practicability of condensing mercurial vapors by compelling them to traverse water in any such way as this. The blast required for such a purpose must be steady and strong, as well as easily controlled. For example, in the vat under consideration, if there were ten of the transverse partitions, making eleven compartments in the top of the vat, and if the water stood one inch above the bottom of the partitions, then the total pressure of the blast must at least exceed that of a ten-inch column of water. Furthermore, the water employed in any such case must become rapidly impregnated with sulphuric, and very likely to some extent with other acids, and would exert a correspondingly rapid destructive effect upon almost everything with which it comes in contact.

In this connection I will mention a fact which should have been stated elsewhere, but it escaped my memory at the time. Mr. Fiedler, the superintendent of the reduction works at New Almaden, informs me that the experiment has been tried here of introducing a jet or spray of water into the interior of one of the condensing-chambers nearest the furnace. This cooled the vapors very rapidly, of course, but was soon discarded on account of a serious drawback, which was quickly discovered, in another direction. The water which flowed from the chamber was found to carry off with it a considerable quantity of quicksilver, which seemed to have condensed in the form of almost infinitesimally minute globules, which would not unite, and which floated in the water like "flour-gold."

There is at the Picacho some chalcedonic, and a great quantity of drusy quartz. The only portion of the mining works which I saw at the Picacho is in the mountain side, close by, and a little above the level of the reduction works. Here a tunnel has been driven about fifty or sixty feet into a gray rock, which is excessively hard and silicious, and which, a few feet beneath the surface, is perfectly compact and solid. I saw no cinnabar here. At the mouth of this tunnel, however, another exploration has been made, by boring into the mountain, at an inclination of about 45°, with the diamond drill, a hole said to be three hundred and fifty feet long. Most of the rock penetrated by this boring was similar to that in the tunnel, very silicious and exceedingly hard, though there were some portions of softer ground where no cores were obtained. No cinnabar was found by this boring, so far as I could learn. But it is now thought by some who helped pay the cost of this operation, that, even if rich ore had been pierced, it might have escaped detection. And indeed this does not seem impossible; for if the ground in which it occurred were soft, there might have been no solid core obtained, the rock crumbling entirely away under the action of the drill; in such a case the ore would be washed out and carried off by the current of water which traverses the hole while the drill is working.

The boring itself was an expensive operation, its cost being stated to have been about $6.75 per foot. It is evident that the diamond drill cannot be used to any great extent for prospecting purposes unless the cost of boring, even in the worst or hardest rocks, can be reduced to a far lower figure than this. It is stated that altogether some $65,000 or $70,000 have been expended here. But I saw no cinnabar except a few pieces at one of the deserted houses. There is nothing doing now, and no one living here.

MONTEREY MINE.

The Monterey Mine is about four miles northwest of the Picacho, and is close to the bottom of the cañon, on the right bank of Clear Creek, a little branch of the San Benito. The croppings here form a heavy mass on the mountain side, whose character (though I had not time to travel over them) appears to be similar to that of the croppings at the Aurora, the Picacho, the Andy Johnson, and other claims in this vicinity, all of which have yielded more or less cinnabar, but none of them any very large quantity.

At the Monterey Mine a tunnel was started close to the bed of the creek and driven in a direction N. 75° W. magnetic directly beneath the huge mass of silicious croppings. I went into this tunnel, which is perfectly straight, for a distance of four hundred and twenty-five or four hundred and thirty feet, and here found it caved so that I did not care to venture farther. How much farther it extended I do not know. But I found in this tunnel nothing but soft rock, chiefly serpentine, and magnesian, clayey rock.

There is a water-wheel standing by the creek near this claim, but what it was used for I do not know. I am told that a furnace of about the same capacity as that at the Picacho was built for this mine at a point a mile or two farther down the cañon of Clear Creek, but I did not visit it. Mr. Morse, the acting superintendent at New Idria, informs me that three or four charges of ore were once burned in this furnace from the Monterey Mine, but that the total amount of quicksilver saved from it did not amount to more than half a flask. He thinks the furnace was a good one, and that the charge was well burned, and that the only reason why more quicksilver was not obtained was that the ore did not contain it. Yet I have seen pieces of very fair ore from the Monterey Mine, though I do not know how much of it was ever found there. The quantity could not have been large, for the mine is now apparently abandoned.

QUICKSILVER MINES NORTH OF THE BAY OF SAN FRANCISCO.

The principal localities north of the Bay of San Francisco where quicksilver was, in 1870, being mined, or where it had recently been obtained, were visited by Mr. Goodyear in the autumn of that year, and the following description of the condition of things, as observed by him at that time, is here appended to his report on the mines of the same metal in the Coast Ranges south of the Bay, which will be found in the preceding pages.*

BUCKEYE QUICKSILVER CLAIM.

A short distance up the first little cañon below Clark's, and on the south side of Sulphur Creek, a tributary of Bear Creek, in Lake County, is the Buckeye Quicksilver Claim, visited by Mr. Goodyear in 1870. Here, at that time, was an open cut some twenty-five feet deep in metamorphic shales and sandstones, which strike N. 75° W. and dip 60° to the southwest. Near the surface these rocks are reddish and ferruginous, but beneath they are grayish and dark-colored. The sandstone also contains nodules of a peculiar rock, resembling pitchstone in appearance. There is a little cinnabar here in irregular streaks, and a belt of rock, some three or four feet in thickness, which is supposed to be "the ledge" is said all of it to contain more or less of cinnabar or native mercury disseminated through it. Below the cut a tunnel had been driven sixty or seventy feet into clay slate and sandy shales, which contained some iron pyrites. There was but little cinnabar visible, however, and no native mercury; neither were the indications such as to warrant any belief in the existence of a metalliferous mass or deposit of any value.

ABBOTT'S MINE.

Abbott's Quicksilver Mine, visited by Mr. Goodyear in 1870, is situated in the mountains south of Sulphur Creek, on the northeast side of a little branch of Harley's Cañon, just east of the head of Grizzly Cañon. Here were two openings, at an estimated distance of fifteen to sixteen hundred feet apart, in a direction of N. 55° W. magnetic. The most southeasterly of these two openings was a tunnel driven some two hundred and fifty feet in a direction N. 25° W. magnetic. Only traces of cinnabar were seen here; but there was much ferruginous gossan-like material, and some of the same rock resembling pitchstone seen at the Buckeye Claim. The rocks at this point are chiefly a pretty thoroughly decomposed, though rather silicious, sandstone, with more or less clay-slate and serpentine. Portions of the rock have been more or less chemically acted on, so as to give rise to various mineral combinations, the nature of which could not be ascertained without analysis.

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* For notices of other localities of quicksilver workings north of the Bay, mostly long since abandoned, see Vol. I. p. 89.

The other excavation, to the northwest of the one just noticed, was an open cut, twelve to fifteen feet deep, and irregular in shape. Here considerably less iron was seen than at the tunnel; but there was much more of the peculiar rock already noticed as having a lustre and fracture resembling pitchstone. This occurs also in abundance at the Redington Mine at Knoxville. At Abbott's Mine it forms masses, apparently segregated, and exactly resembling the rounded boulder-like ones which so often occur in the more or less perfectly formed serpentines throughout the Coast Ranges. This rock frequently contains little cavities partially filled with volatile hydrocarbon oils, which on exposure to the atmosphere lose their more volatile portions and thicken rapidly. At the Redington Mine, where these oils often ooze from the rock in small quantity, they rarely run far down its surface, but gradually form little ridges, a few inches in length, of gummy matter, precisely resembling in shape those formed on the sides of a candle by the trickling down of melted tallow.

In the open cut at Abbott's Mine the cinnabar was seen lining cracks and seams in this rock, and more or less generally distributed through the earthy matter lying between its masses. The same rock also contains a good deal of pyrites or marcasite, and there is some chalcedonic quartz scattered through it. In regard to the prospects of Abbott's Mine, Mr. Goodyear remarks that the quantity of cinnabar in sight was not sufficient to prove the mine to be a valuable one, although there was enough to encourage "prospecting," if done in a judicious and economical manner.

BAKER'S MINE.

Baker's Quicksilver Mine is a little beyond the crest of the divide between the waters of Clear Lake and the head of Soda Creek, which runs in a southeasterly direction to Puta Creek. Here some prospecting has been done, although no large bodies of ore had been discovered up to the time of Mr. Goodyear's visit. Cinnabar and the black ore of mercury (metacinnabar*) occur here, however, together with considerable quantities of pyrites or marcasite, which runs in thin seams in all directions through the cavernous rock. There is also considerable calcite, in the form of nail-head spar. The quantity of ore seen at this locality would indicate that the chances for successful prospecting were fair. It appears, however, that, instead of settling this point by proper explorations at the place where the ore was found, the owners, being satisfied that they had "a good thing," expended all their money in driving a tunnel some four hundred feet long, which was intended to strike the deposit of ore at considerable depth; this work, however, they were obliged to abandon before any results were obtained. None of the explorations in this vicinity had, up to 1870, proved successful.

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* A peculiar ore of quicksilver, having the same composition as cinnabar, but distinguished from it by its black color and streak, and lower specific gravity. It was first noticed by me in 1863, and specimens given to Dr. G. E. Moore for examination. His published account of this interesting variety will be found in the American Journal of Science, Series 3, Vol. II., in the number for January, 1872. — J. D. W.

MANHATTAN MINE.

The Manhattan Mine, at Johntown, lies about two miles by the road northwesterly from Knoxville. The rocks near the mine are chiefly metamorphic sandstones and clayey beds, with more or less serpentine, traversed by frequent reticulations of quartz, etc. The Manhattan Mine itself is in the summit of a round-topped hill about one fourth of a mile northwesterly from the old Johntown Mine. This hill is a mass of chalcedonic quartz, much broken into large fragments. Most of it is banded, some of it in very thin layers. The crevices which seem to have been formed in it from time to time and then more or less refilled with chalcedony contain most of the cinnabar, which thus forms an irregular network of reticulating veins, though it is more or less distributed throughout a great portion of the more solid and compact rock. The chief cinnabar-bearing crevices, however, seem to strike from about N. to N. 25° W. magnetic, and dip easterly from 20° to 50°, the dip being generally least at the northwest end of the hill. There are large quantities of drusy quartz crystals here, some calcite, much sulphuret of iron, some of the black ore of mercury, a transparent mineral in tabular crystals which I did not recognize, and also sulphuret of antimony (stibnite) in little bunches of acicular crystals.

The outcrop in this hill covers from one and a half to two acres, and seems to have been formed by the action of silicious springs and vapors bringing up the minerals from below through crevices, and probably irregular ones, in the broken metamorphic rocks. This very heavy mass of chalcedonic quartz appears to be local, i. e. there is no other mass known about here that is so heavy. But there are reticulations and smaller bodies of similar rock running on for some distance to the northwest, and a little cinnabar has been found in spots for two or three hundred yards in this direction.

The ore coming from the mine is sorted, and the yield of the assorted ore was said to range from three to five per cent. This, however, seems to me an exaggerated estimate. It goes into a large square furnace-chamber which is said to hold about eighty tons of ore. The fireplace is on one side at the bottom, and the flames with all the products of combustion pass directly into and through the ore, the mercurial vapors passing out with them through holes in the opposite side of the chamber into the condensers. The ore is treated alone by itself in the chamber, no lime, nor anything else, being added to it. Chamisal brush is the only fuel here used.

The condensers are cast-iron boxes with rectangular horizontal, and trapezoidal vertical sections. They are about nine feet long, four feet wide at the bottom, three and a half feet wide at the top, four feet high at the front end, and three feet four inches high at the rear. Each condenser is said to weigh about eleven hundred pounds, and is provided with a vertical rim cast upon it around the edge at the top, so that the whole top of the condenser forms a level shallow trough, which is kept filled to overflowing with water; this constantly and slowly trickles down over the slightly inclined exterior of the walls of the condenser. There is a series of fifteen of these condensers side by side, the water for cooling them being supplied by a pipe which runs transversely across their tops from one end to the other of the series. The gases pass through all of these condensers in succession, a good draft throughout the furnace and the whole apparatus being maintained by an exhausting-blower placed at the end of the series and driven by a small steam-engine.

It was stated by Mr. Clarke that nearly all of the mercury condenses in the first six or eight of the condensers, the latter half of the series saving but very little. The sulphurous acid, also, is said to attack the condensers slowly, so that the latter last a good while. The exhaustive blast, of course, diminishes greatly the chances for any salivation of the men about the furnace and condensers. The residual gases from the blower are driven off through a board flue some three hundred feet long before being discharged into the air, and this flue itself is graded in such a way as to catch and collect any portions of mercury which might condense here, its bottom being also covered with some impervious coating.

The furnace was idle at the time of my visit, but I was informed that when in blast it is kept constantly running, about a ton of ore being charged at the top of the chamber and a corresponding quantity drawn out at the bottom, at intervals of about an hour, day and night, so that the run amounts to about one hundred and seventy tons per week. Mr. Clarke informed me that the last week's run previous to my visit had produced seventy flasks of mercury. But I understood afterwards that this included the results of a thorough cleaning up of the whole apparatus, and that their average production when running had not exceeded about forty flasks per week. This would be far from corresponding to any yield of "from three to five per cent" from one hundred and seventy tons of ore. This was the only mine being worked at Johntown at the time of my visit, and I was informed by Mr. Clarke that it was less than two years since this mine was opened, while it was still more recently that the furnace was erected and put in working condition. Mr. Clarke also stated that at the time of my visit they were employing ninety men.

The works at the mine so far were chiefly surface openings, very irregular in form. But there were also three or four short tunnels running into the hill from different points in converging directions. There was exposed here at that time a large body of rock containing more or less quicksilver. But there appeared to be very little high-grade ore, and what proportion of the mass would pay to work at all I do not know, but am inclined to think the percentage a small one. The character of the gangue is very different from that of any other quicksilver mine or claim which I saw anywhere in this region of country, no other one being, as this is, in chalcedonic quartz.

The ridge just north of the Manhattan Mine is capped with lava, which stretches eastward, and covers also a broad-topped hill about half a mile magnetic east from the mine. The rock employed for building the furnaces, etc., came from two quarries, one of them situated, I estimate, about half a mile southwesterly, and the other one about a quarter of a mile a little west of south from the mine. This rock is chiefly, at least, a mass of volcanic ash, consolidated, and enclosing occasional small fragments also of metamorphic rocks. But some portions of it present a texture and appearance which is very strongly suggestive of a more or less vesicular and cavernous lava most thoroughly decomposed but not disintegrated. I visited the nearest quarry and obtained specimens of the material, which varies considerably both in hardness and in color, and also greatly in texture from coarse to fine, and from cavernous to compact. The deposit is not very deep, and it rests upon metamorphic rocks. It is bedded, and I found at one point its strike to be about N. 40° W. and its dip about 10° to the northeast.

Mr. Clarke informs me that in the old Johntown Mine a tunnel some four hundred feet in length, which is now caved in, pierced at one point a considerable body of volcanic rock with shales on both sides of it, which had every appearance of a dyke, and that immediately adjacent to this volcanic rock they found in the tunnel some very handsome crystallizations of cinnabar.

THE REDINGTON MINE.

This mine is situated at Knoxville, just within the borders of Lake County, and is the same one which is noticed as the Excelsior Mine on page 92 of Vol. I.*

The locality of the Lake Mine was pointed out to me as being low down on the northern or northeastern side of the same ridge, near the summit of which, and just south of its highest crest, is situated the Manhattan Mine. But a short distance east of the Manhattan Mine this ridge falls off rapidly in height and connects only through a low saddle just north of Knoxville with the hills which again rise much higher towards the great unaltered cretaceous ridge to the east. This saddle is also the divide between the heads of Eticuera Creek, which runs to Puta Creek, and Davis's Creek, which runs northerly to Cache Creek.

The hill in which the Redington Mine is situated consists of very highly altered rocks, whose original character it is not altogether easy to predicate now, though much of it looks as if it might once have been serpentine. Near the surface the more or less decomposed rock is deeply but very irregularly stained with iron, but in the deeper levels of the mine it is undecomposed and full of sulphide of iron, much of which, however, is certainly not pyrites, but probably marcasite, as its crystals, of which I obtained some very fine specimens, are thin-tabular in form. Here, also, there are large quantities of the peculiar rock so suggestive of pitchstone, already noticed at Abbott's Mine and elsewhere, though generally it does not seem to be quite so vitreous in its appearance here as was much of that at Abbott's.

One of the most constant features of the Redington Mine is a large clay-seam traversing the ore-bearing rock and curving more or less irregularly about, but generally striking from N. 25° W. to N. 50° W. magnetic, and dipping N. E. from 40° to 50°. From this main seam branch seams run out here and there, and others cross it irregularly. Mr. Williams, the mining superintendent, states that, as a rule, the larger bodies of ore in this mine are surrounded on all sides by clay seams, though this is not always the case. The "main clay seam" varies in thickness from a few inches to thirty feet or more, and the best ore is said to be generally found in the rock beneath, but near to, this main seam. The richest ore occurs chiefly in thin irregular seams. Sometimes these seams show a thickness of two inches or more of nearly pure and compact cinnabar, but such are exceptional. The greater portion of the cinnabar here may be said to be in one sense distributed throughout large irregular masses of rock, which in working the mine form a series of irregular chambers of ever-varying shape and size. But in reality probably more than nine tenths of it all occurs in small cavities and thin reticulating seams which traverse the rock in every direction. It is rare that a good-sized lump of the richer ore is anything like so rich throughout its mass as the appearance of its exterior would seem to indicate. In such pieces the exterior is very apt to consist of only an incrustation of cinnabar, often mingled in large proportion with the black ore metacinnabar, the interior being simply traversed to a greater or less extent by similar seams. The quantity of this black ore in the mine is very large, and it forms apparently a considerable percentage of all the ore extracted. And though it appears that the examples tested by Mr. G. E. Moore were not crystalline, yet the commonest mode of occurrence of the black ore in this mine *is* crystalline, and in the form of incrustations consisting of botryoidal aggregations of minute crystals, so small that their form cannot be determined with a pocket-magnifier only. A very large proportion of the red cinnabar here is also crystallized in minute and delicate crystals, and the marcasite also is largely crystallized. Indeed, the strong tendency to crystallization of the different minerals appears to be a peculiar, as it certainly is a very striking characteristic of the Redington Mine.

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* Prior to 1867 the Redington Mine was owned by the X. L. C. R. Mining Company of Napa City, and had been leased to the Lake Manufacturing Company for six years for a rental of six cents per pound on all quicksilver taken from the mine, the total product during the lease amounting to sixteen thousand two hundred and nineteen flasks. In November, 1867, the X. L. C. R. Company was reorganized as the Redington Quicksilver Company.

The sulphuret of iron is also everywhere distributed throughout all the deeper portions of the mine, and its quantity is very great. Much of it is massive in form, but, besides this, the seams are everywhere more or less coated with tabular crystallizations of it in the form of cock's-comb pyrites. Crystalline gypsum, also, occurs near the surface in the upper portions of the mine.

Good ore was found in this mine from the surface down. Two tunnels have been driven into the hill from different points, and the Redington Shaft had been sunk at the time of my visit to the depth of something over one hundred and fifty feet, and two levels driven from this shaft at depths of ninety and one hundred and fifty feet respectively below its mouth. The Meat-House Tunnel starts in near the Redington Shaft, and a few feet higher than its mouth, and runs southwesterly for a distance of something over two hundred feet, to ore-bearing ground. The Main Tunnel starts in some three hundred and fifty feet farther south, and runs not far from N. 75° W. magnetic to ore-bearing ground, then bears more northerly, and then westerly again. The 90-foot level runs from the shaft, first southwesterly and then curves around through the ore-bearing ground to the northwest. The 150-foot level runs first a little south of west magnetic some two hundred and forty or two hundred and fifty feet from the shaft, and then also bears northwesterly.

At the time of my visit there was a considerable body of good ore exposed in the 90-foot level, and also a considerable quantity of ore still standing in places in the upper parts of the mine among the old workings. But appearances in the 150-foot level were not so good. Speaking generally, the main body of the ore-bearing ground, so far as explored in this mine up to the time of my visit, may be said to have a major axis which bears about N. 30° W. magnetic, and a general northeasterly dip at a pretty high angle. But it must be remembered that this is not a continuous body with definite outlines, but a series of irregular chambers, of which the most that can be said is, that their relative situations and arrangement as a whole form a cluster whose position approximates that described above.*

The average yield of the assorted ore which goes to the furnaces here was stated by Mr. Mahon to be about eight per cent. The ore is fed to the furnaces in lumps as it comes from the mine. Its character is such, however, that in the operations of handling and sorting it produces a large quantity of fine dust which is rich in cinnabar. This dust is made into bricks and sun-dried, in the manner of adobes, and these bricks are then used in certain proportions with the lump ore in charging the furnaces. The number of furnaces employed here is two, and these are stated by Mr. Mahon to hold respectively fifty-eight and sixty-five tons of lump ore, exclusive of about six tons of adobes in the first and thirteen tons in the second, thus making the total charges of the two furnaces sixty-four and seventy-eight tons respectively. And he informs me that for six months during the year 1870, taking the work of the two furnaces together, and estimating an average of seventy tons of ore per furnace-charge, the total average yield was at the rate of 46,040 lbs. of mercury from every 576,000 lbs. of ore, which is equivalent to 7.993 per cent.

The furnaces with their condensing-chambers are massive structures, built entirely of the rock from the volcanic ash-quarries near the Manhattan Mine. A vertical section of the ore-chamber of the furnace in either direction is rectangular. A horizontal section shows the longer sides to be straight and the ends to consist of arcs of circles convex inward. Indeed the end walls of these chambers are portions of vertical right circular cylinders, and pierced full of holes the size of a brick for the passage of the gases. At one end of the ore-chamber, behind the perforated wall, is the furnace proper, i. e. the fireplace. The furnace gases pass from the fire immediately into and through the mass of ore in the chamber, and issuing with the mercurial vapors through the perforated wall at the opposite end of the chamber, are first made to pass through three successive large condensing-chambers built in the same pile of masonry with the furnace itself. But I am informed that very little mercury is obtained from either of these three chambers, which all become too hot to permit it to condense much here.

Each furnace, with its three attached condensing-chambers, forms a separate block of masonry. These two blocks, however, are built adjacent to each other, end to end, with only a narrow passage between them, the condensing-chambers of each furnace being at the end adjacent the other one, and the fireplaces at the opposite or outer ends. A few feet from these furnace blocks, and opposite and facing the narrow passage-way between them, is the end of the third large block of masonry containing the condensing-chambers proper. This block is built of masonry throughout, the same material being used as in the construction of the furnaces themselves.

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* A survey and map of this mine was made during the summer of 1870 by Alfred Poett.

Its interior is separated by transverse vertical walls into a series of twelve large condensing-chambers, each in the form of a narrow, but high and long, rectangular parallelopipedon. Two large flues, one from the top of the last of the three condensing-chambers in each of the two furnace blocks, conduct the vapors into the two upper corners of the first of the series of these larger chambers. From here they pass through a single aperture of one of the lower opposite corners into the second chamber. Thence following the direction of a diagonal of the parallelopipedon, they pass through the diagonally opposite upper corner into the third chamber, thence through the diagonally opposite lower corner into the fourth one, and so on, continuing to follow the diagonals of all the chambers to the end of the series, whence they pass through an inclined flue of not very great length to the foot of a stack some twenty-five or thirty feet high at the summit of an adjacent hill.

There is no blower employed, and the only draft throughout the whole arrangement is that produced by the furnace fires and the stack ; but, as this is sometimes insufficient, a fireplace is provided at the foot of the stack where an auxiliary fire can be built when required. This is badly arranged, since in order to build the fire here it is necessary to open the iron door at the foot of the stack, and when the draft in the furnace is bad, the immediate consequence of opening this door is such an efflux of suffocating and poisonous gases as frequently not only renders all access to the door itself for a time impracticable, but also has a strong tendency to extinguish fire, so that it is sometimes only after much time and trouble, by building the fire at first at some distance from the door, and after it has gained some strength by gradually pushing it towards the entrance, that its heat can be at last sent through the stack and the draft in the furnaces restored.

I was informed that the largest quantity of mercury condenses in the second chamber of the twelve, and that from here on the quantity obtained from each chamber rapidly diminishes. But there is nevertheless a very appreciable quantity which passes on through all the chambers and the flue beyond, and escapes at last from the top of the stack. The sulphurous acid from the stack effectually kills all vegetation on the surface of this hill for several hundred feet around.

The tops of the condensing-chambers are covered with shallow pans kept filled with water to assist in cooling the vapors ; but these tops are small compared with their remaining surface. The chambers themselves are quite massive, and the material of which they are built is a poor conductor of heat ; besides they are all connected together in a single block. From all these circumstances it results that the cooling of the vapors, even at the best, is by no means as rapid and complete as it is desirable it should be. There are also two other disadvantages connected with this heavy system of condensing-chambers. The first is, that it is very expensive ; for although the stone is soft, to be sure, and easily worked, yet it is all dressed to ashlar form and carefully laid, and the structure is heavy and strong. The second is, that the porous nature of the material permits it, to a considerable extent in the condensing-chambers, but to a far greater extent still in the furnace-blocks, to absorb large quantities of mercury.

These furnaces are not worked continuously, but intermittently, each charge being entirely worked out and removed before the furnace is again recharged. The usual time required for the reduction and removal of a charge and the recharging of a furnace is a week. At the time of my inspection of the works, it was Saturday afternoon, the furnace had been cleaned out after the exhaustion of the last charge, and the work of recharging had just commenced. The ordinary programme is as follows: The work of charging the furnace is finished on Monday. The fire is lighted on Monday evening, and kept up steadily till Thursday night. On Friday morning the exhausted charge is drawn hot from the ore-chamber into iron cars and discharged upon the dump. All the doors are opened and the furnace then left to cool as rapidly as possible. On Saturday morning, having become cool enough, so that it can be entered by the workmen, the ore-chamber is thoroughly cleaned out, and on Saturday afternoon the work of recharging is begun.

In charging the furnace, the adobes, i. e. the bricks of ore dust which are used, are first built up in a thin wall around the sides of the ore-chamber, forming as it were a sort of lining for the interior of the chamber. The balance of the ore is then charged in lumps, little flues being constructed through it to some extent with adobes. The reduction is effected entirely by the atmospheric oxygen, no lime being employed. Oak wood is used for fuel, and the consumption is stated to be from two and a half to three cords per furnace-charge of ore.

The material of which the furnaces, etc., are built, does not fuse at the temperatures here employed, but the action of the furnace gases appears to slowly corrode it. As already stated, it is very porous, and the mercury penetrates it largely and impregnates more or less its whole mass. Mr. Mahon informs me that the first charge ever worked in one of these furnaces was an exceedingly rich one, containing probably seventy-five per cent of mercury, and being the pickings and dressings of some two thousand tons of ore. It is not stated whether it was a full charge for the furnace or not. But they expected to obtain from it between two and three hundred flasks of mercury. The furnaces and chambers, however, were all new and porous, and not quite dry; and as they used fifteen cords of wood, the whole arrangement was heated to such a point that the mercury went into the rock, out at the chimney-top, and all over the country, so that only about half a dozen flasks were saved from that whole charge.

The above description of the furnaces is chiefly from my own observations. But statements relating to the manner of working them and the results obtained are chiefly from information kindly given me by Mr. Thomas Mahon, the general foreman of the company.

Mr. Hall, the clerk of the company, informed me that at the time of my visit they were producing about four hundred flasks per month, and employing about one hundred and eighty men.

I have elsewhere mentioned both the fact and the mode of the occurrence in many parts of this mine of certain hydrocarbon oils. I may add in connection with this, that at one time they had in a portion of the mine some trouble with the ventilation, due to carbonic acid gas. But they have never been troubled here, so far as I could learn, with any explosive gases, though small quantities of such gases have been occasionally ignited in the mine.

THE ANDALUSIA AND REED MINES.

On going northerly from Knoxville to the crest of the low divide between Eticuera and Davis's Creeks, the road all the way is strewn with volcanic boulders which came from the hills on the west. From this divide a little branch of Davis's Creek runs northwesterly for a mile or two, and meets a nearly equal branch coming in from the opposite direction. These two little branches lie almost in the same straight line northwest and southeast, and it is on the southwest side of the short but deep cañon of the northwestern branch that the Reed and Andalusia Mines are situated. The Andalusia is about four miles northwest of Knoxville, and the Reed three fourths of a mile southeast of the Andalusia. Immediately southwest of the point where these two little branches unite, there is on the northeastern slope of the hills a broad surface of volcanic rock covered with boulders of the same material, and presenting every appearance of being a local lava-flow from near the crest of the ridge back, or northwest of, the Manhattan Mine.

At the Andalusia Claim two tunnels have been driven into the mountain, the one about one hundred feet in a westerly direction, and the other some three hundred feet in a direction about S. 70° W. magnetic. These tunnels traverse chiefly either serpentinoid rock more or less broken and crushed, or else a strong tough clayey material, which seems to have resulted from the partial decomposition of a similar rock in place. In the longer tunnel I found some drusy incrustations of pyrites, whose crystals were so minute that with my pocket magnifier I could not certainly distinguish their form, though I was inclined to think them octahedral. Hydrocarbon oils ooze also from little cells and cavities here and there, and form pitchy spots, as in the Redington Mine and elsewhere. But the quantity of mercury was very small, the most that I saw being perhaps a ton or two of pretty good ore lying near the mouths of the tunnels. Most of the rock in this vicinity which contains traces of cinnabar is very silicious, but presents an appearance strongly suggestive of a serpentine which has lost a portion of its magnesia. The mass of this rock here is very heavy, covering the crest of the spur for some distance west and northwest from the tunnels. A little prospecting has been done at various points, but at none of these did I see more than traces of cinnabar.

The Reed Mine, three quarters of a mile farther down the creek, is some four or five hundred feet above its bed. No tunnelling of any account has ever been done here, with one exception, an old tunnel now caved in, which is said to have been driven some five or six hundred feet with little result. The ore hitherto extracted from this mine has come chiefly from a single large open cut some distance farther up the hill. Here at the time of my visit was a pile of perhaps one hundred tons of selected ore, which appeared to me to be of decidedly a low average grade, but which was the total product, if I was correctly informed, of the picking and sorting of some two thousand tons of extracted rock. The ore here was almost exclusively the "black ore," very little red cinnabar being seen.

At the time of my visit here Mr. John Roach, optician of San Francisco, was engaged in putting up some experimental reduction works at the Reed Mine, of the following description: First, a furnace of boiler-iron lined with fire-clay in the form of a simple upright cylinder of twenty-six inches interior diameter and eight feet high, with a small hopper at the top provided with a slide-valve for charging the furnace. At the bottom of the cylinder are a few grate-bars, set wide apart, with a small space beneath them for starting the fire, etc. This furnace is to be charged with ore and fuel either mixed or in alternate layers; a fire is then started beneath the grate-bars, and the work begins and is kept up continuously. The residue of the exhausted ore, together with the ashes, etc., falls through the bars and forms a talus beneath, and is from time to time removed with the shovel, fresh portions of ore and fuel being added at the top.

The gases pass out through an aperture in one side of the furnace just beneath the top, and immediately enter another vertical cylinder of equal size which stands side by side with the furnace. This cylinder is intended for a condensing-chamber, and is furnished at the bottom with a pipe for drawing off the liquid mercury, and also with a small door for cleaning out soot, etc. But this cylinder is perfectly simple, having no internal partitions, and the vapors are not compelled to travel its length at all; on entering it from the furnace they simply descend two or three feet, and pass immediately out again through iron pipes on the opposite side. There are two of these pipes side by side, each of them eight inches in diameter. They run straight, with a very slight descending grade from the furnace, about twenty feet to the first one of two wooden condensing-vats. Immediately over and along the whole length of each of these pipes there also extends a little water-pipe pierced with numerous small holes through which cold water trickles over the larger pipes to cool them. The wooden vats are each of them circular, about five feet in diameter and six feet high; they are filled to a certain height with water. The pipes from the furnace descend into the first vat and dip about four inches into the water. From the top of this vat an exit-pipe conducts the vapors into the second one, where it also dips similarly into the water. From the top of this vat another pipe leads them into the air-tight casing of an Archimedes-screw blower, which compels them again to traverse the water here, after which they are discharged. This blower is driven by a little steam-engine of three-inch piston and eight-inch stroke, and its exhaustive action draws the vapors through the water in the two cylindrical vats and produces also all the draft in the furnace.

I have very serious doubts as to the efficacy of the iron cylinder adjacent to the furnace as a condensing-chamber, in spite of the fact of which Mr. Roach assures me, that in his experiments there subsequent to my visit he obtained from this chamber a quantity of condensed water, mingled with pyroligneous acid and other products resulting from the partial distillation of the wood employed as fuel. Mr. Roach informs me further, however, that the results of experiment up there since my visit have indicated several important improvements, which will be made in this apparatus soon, and which are expected to give greatly improved results. I think they will, *provided* they are of the proper kind!

STATISTICS OF NEW ALMADEN.

DATES.	No. of Months.	No of Furnace Charges.	ORE REDUCED: POUNDS AVOIRDUPOIS.				QUICKSILVER PRODUCED.			Total Average Percentage yield from Furnaces.	Estimated Percentage Value of Tierras alone.	Av. per-cent yield of Ore, deducting Tierras at value estimated in preceding column.	Average Number of Flasks per Month.
			GRUESO.	GRANZA.	TIERRAS.	TOTAL.	From Furnaces. Flasks.	From Washings. Flasks.	Total Pounds Avoirdupois.				
July, 1850 to June, 1851	12	...	....	....	....	4,970,717	23,875	....	1,826,437	36.74	......	......	1,989½
" 1851 " " 1852	12	...	....	....	....	4,643,290	19,921	....	1,523,956	32.82	......	......	1,660
" 1852 " " 1853	12	...	....	....	....	4,839,520	18,035	....	1,379,677	28.51	......	......	1,503
" 1853 " " 1854	12	...	....	....	....	7,448,000	26,325	....	2,013,862	27.04	......	......	2,194
" 1854 " " 1855	12	...	....	....	....	9,109,300	31,860	....	2,437,290	26.75	......	......	2,655
" 1855 " " 1856	12	...	....	....	....	10,355,200	28,183	....	2,155,999	20.82	......	......	2,348½
" 1856 " " 1857	12	...	....	....	....	10,299,900	26,002	....	1,989,153	19.31	......	......	2,167
" 1857 " " 1858	12	...	....	....	....	10,997,170	29,347	....	2,245,045	20.41	......	......	2,445½
" 1858 " Oct. 1858	4	...	....	....	....	3,873,085	10,588	....	809,982	20.91	......	......	2,647
Nov. 1858 " Jan. 1861	27					Mine	closed	by In	junction.				
Feb. 1861 " " 1862	12	...	....	....	....	13,323,200	32,402	2,363	2,659,522	18.60	......	......	2,897
" 1862 " " 1863	12	...	....	....	....	15,281,400	39,262	1,129	3,089,911	19.65	......	......	3,366
" 1863 " Aug. 1863	7	...	....	....	....	7,172,660	17,316	2,248	1,496,646	18.47	......	......	2,795
Sept. 1863 " Oct. 1863	2	...	....	....	....	(2,346,000)	....	....	422,280	(18.00)	......	......	2,760
Nov. 1863 " Dec. 1863	2	31	54,800	1,586,500	719,000	2,360,300	4,040	407	340,195	13.09	3	17.52	2,223½
Jan. 1864 " " 1864	12	301	1,259,400	18,730,300	3,287,900	22,527,500	42,176	313	3,250,408	14.32	3	16.25	3,540¾
" 1865 " " 1865	12	352	2,288,900	25,749,000	3,910,500	31,948,400	47,078	116	3,610,341	11.27	3	12.43	3,933
" 1866 " " 1866	12	277	1,506,000	19,939,100	5,440,200	26,885,300	34,726	424	2,688,975	9.88	3	11.62	2,929
" 1867 " " 1867	12	271	731,500	15,689,288	9,603,145	26,023,933	23,990	471	1,871,266	7.05	3	9.42	2,038½
" 1868 " " 1868	12	301	2,274,208	14,566,600	12,564,722	29,405,530	25,577	51	1,960,542	6.55	2	10.12	2,135⅔
" 1869 " " 1869	12	...	150,000	11,942,175	13,365,987	25,457,700	....	....	1,292,697	5.07	2	8.48	1,408
" 1870 " " 1870	12	220	30,000	12,531,900	8,535,800	21,097,700	....	....	1,103,359	5.23	2	7.42	1,202
						290,365,805			40,167,549				

Total product of the New Almaden and Enriquita Mines, to January 1, 1871 = 535,637 Flasks.

Average percentage yield of all ores worked at New Almaden during first five years, ending June 30, 1855 = 29.61 %.
" " " " " " " five and a half years, ending Dec. 31, 1860 = 20.27 %.
" " " " " " " five years, ending " " 1865 = 15.66 %.
" " " " " " " " " " " " 1870 = 6.92 %.
" " " " " " " first ten and one half years, ending Dec. 31, 1860 = 24.62 %.
" " " " " " " ten years, ending Dec. 31, 1870 = 10.63 %.

Total average yield of all the ores extracted and worked rom the New Almaden Mine for twenty and one half years, from the opening of the Mine, in July, 1850, to December 31, 1870. } = 13.83 %.

H.

NOTES ON THE GEOLOGY OF LOWER CALIFORNIA.

BY WM. M. GABB.

THE Peninsula of Lower California can be separated geologically into three pretty well marked districts. The first includes the high mountain portions between La Paz and Cape San Lucas; the second extends from this to beyond San Ignacio, say to Santa Gertrudis; the third includes all that part lying north of Santa Gertrudis. The date of the upheaval of the mountain ranges, as proved by the sedimentary rocks which are disturbed, allies them to the Coast Ranges of Upper California, with which, in fact, they are connected by a continuous chain. It is possible to trace an uninterrupted granite ridge from the San Gabriel Mountains, north of Los Angeles, through Los Angeles, San Bernardino, and San Diego counties, into Lower California and along the Peninsula to within a few miles of the old mission of Santa Gertrudis. From the exposure by denudation of masses of granite under the sedimentary rocks, as at Santa Gertrudis and again near Loreto, it is probable that an elevation of say another thousand feet would carry the continuous line of granite entirely through to Cape San Lucas. This will be better understood by a more detailed account of the various phenomena observed during our hasty reconnoissance.

The first region mentioned above consists of a high, nearly north and south range of mountains, commencing at Cape San Lucas and extending with its branches to the Cacachilas range, southeast of La Paz. Other spurs and accessory chains cover nearly the whole lower extremity of the Peninsula with a rugged mountain mass, very variable in height and interspersed with almost innumerable valleys, some of which can scarcely be equalled in beauty and fertility by any other part of the world. Even high up in the mountains are said to be fine valleys, well watered, with a constant supply of the best of grass, capable of raising anything; and, what is most important of all in a country where wood is scarce, surrounded by the finest kinds of oak and pine timber.

The main chain of this region is the San Lazaro, a mass lying west of the valley of San José, and culminating in the sharp peak of San Lazaro, about five thousand feet high. This range is extremely rugged and picturesque, and appears to be heavily timbered, at least in parts, as seen from the valley at Santa Anita. It sends out many lateral spurs, and its deep cañons all abound in perennial supplies of excellent water. The coast side, as seen from a passing vessel, is even more barren and forbidding than its inland aspect. At its southern extremity it opens into a Y shape near Cape San Lucas, and north it sends out several branches, one of which, the Sierra de la Victoria, some thirty miles south of Triunfo, rivals the main chain in height. Triunfo itself is in a low part of the same range, and within a mile or two of the dividing ridge which forms the water-shed between the Pacific and the Gulf of California. Here, however, the elevation is perhaps not more than a thousand feet above the sea, and the descent is almost unnoticeable except to an experienced eye.

The same ridge rises again on the peninsula included between Paz Bay and the Gulf, making the rugged granite chain of the Cacachilas, perhaps three thousand feet high. In the tract included between the ranges above mentioned and the east coast, that is to say, between a nearly direct line from San José to La Paz on the west and the Gulf on the east, there are numerous small ranges and spurs, none of great elevation, and which we had no opportunity of examining in detail. The geology of the lower portion of the Peninsula is quite simple. The high ridges are all essentially granite, the rock varying in structure from a true granite to a true syenite, with every intermediate gradation. Approaching San Antonio from the southeast, the granite is found to be replaced, for the first time, by mica slate, which forms a belt running across the country from northeast to southwest. I found it extending uninterruptedly to, and six miles beyond, Triunfo on the La Paz road. To the west, from towards Todos Santos, it continues to the extreme edge of the mountains bordering the plains, and it is said to extend to the Cacachilas. It is in this rock that the only really valuable mineral deposits of the Territory have been found. Gold is reported from many places in the granites of the San Lazaro; and Señor Carillo, of Santa Anita, assured me that, when a young man, he had seen "chispas" or nuggets of gold, one as large as the palm of his hand, said to have been brought from the low ranges east of Santa Anita. Be that as it may, subsequent search has always failed to find the spot from which they came. Copper and silver are also reported, and traces of the former, at least, doubtless exist. At the Calabazas, eighteen miles from Triunfo, on the road to La Paz, in a low ridge to the left of the road, copper-mines or traces of copper exist. No work is being done, the explorations having ceased long before our visit. In the mica slate only have deposits of ore been found sufficiently valuable to pay for regular mining. The principal districts are, the vicinity of San Antonio and Triunfo, within three or four miles of each other, and containing the same system of veins, and the district of Cacachilas on the southeast side of the range of mountains of the same name, and between twenty and thirty miles from La Paz. This latter district was not examined by us, for a variety of reasons. Our purpose in visiting the country was to make an exploration of the lands included within the grant to the Colonization Company, and these did not commence until some distance farther north. We were in a hurry to get at our legitimate work, and our time was necessarily limited; besides, having ascertained the main features of the mineral deposits, we had no inclination to go into the details of every mine. We spent several days in and around Triunfo and San Antonio, and visited all the principal mines of that region. They are almost all on two parallel veins, running nearly north and south, and quite near each other. The largest of these veins is remarkable for the great uniformity it exhibits throughout, not only in its dimensions and continuity, but in the character of the ore it contains. The vein, having itself a thickness of from eight to fifteen feet, shows a body of ore of from three to five feet in width at all points where deep excavations have been made on it, within a length of four or five miles. Several mines are in successful operation on this vein, and several others have been sufficiently opened to render their future morally certain of success, so far as one dare judge one mine by analogy with another. The injudicious expenditure of large sums by incompetent men, in doing useless work, instead of applying it in such a manner as to prove the vein, has retarded, almost beyond calculation, the development of this region. It will require years to restore the confidence thus lost, and establish on its proper basis the prosperity of the district. The mistake always made has been the employment of men unfitted by study and experience as superintendents of the mines, simply because their services could be obtained at a price which, when too late, was found to be in a nearly exact ratio with their ability. Besides the two principal veins, there are several smaller ones on which there are many mining claims; but inasmuch as work has been many times commenced and abandoned on them, and no results ever yet attained, it is probably safe to pass them by with a mere mention.

Besides the crystalline rocks already described, there are some deposits of later age in this district, although these are very limited in extent. They belong to two distinct geological eras. The newer is a modern gravel deposit, which fills nearly all the valleys, is horizontally stratified, and consists of *débris* of granite, with some foreign admixture, such as boulders of volcanic origin. This gravel forms mesas, in some places as much as sixty feet above the valleys, perfectly level, nearly always covered with loose stones, and supporting an entirely different character of vegetation from that found in the fertile bottom. Sometimes, as at the Cuevas, it is a pretty compact, even-grained sandstone, which at times is a little disturbed, having a dip of a few degrees in one direction or another. It fills the valley of San José, bordering its sides, either as a regular table or occasionally cut up into rolling hills. From the head of the valley between Santa Ana and Santiago, it lies along the summit of the divide between the two streams. At Santiago it is a mile or two wide, and forms a beautiful terrace with a sharply defined margin and steep face.

The other rock — probably the same as that so extensively developed farther north in the mesas — is a hard sandstone resembling closely that of the Tertiary of Upper California. The only place where I saw it well developed in this region was at the Rancho de los Martires, where east of the house is a little hill composed of strata dipping westward at an angle of about fifteen degrees. The rock, of which I saw much in use about the house, is said to be all alike. It is a fissile sandstone, splitting into sheets, and answering admirably for flagging. The horizontal gravels abutted against the sloping face of this rock. I saw no fossils in it, nor was there any way in which I could even approximately establish the age of the formation. Large fossil oysters are said to occur three miles east of Santiago, but I was reluctantly obliged to leave without visiting the locality. The only clew I possess is indeed a slight one. About seven years ago Mr. John Xantus sent from Cape San Lucas to the Academy of Natural Sciences of Philadelphia a few fossil oysters. These were considered at the time by Mr. Conrad and myself as probably belonging to his species *O. Georgiana ;* but a more intimate acquaintance with *O. Titan*, Con. in California inclines me to the belief that they were the long, slender variety of that species. Should *O. Titan* be found in this rock it would be pretty good proof of the Miocene age of the formation, since that species is very characteristic not only of this formation but of a single member of it. Throughout the whole extent of the Territory, I never encountered a single fossil in the Mesa Sandstones, and while I consider that analogy and all the little items of presumptive evidence which can be obtained are in favor of their Miocene age, I should notwithstanding feel considerable hesitation in saying positively that they belong to this formation.

On the road from Triunfo to La Paz, after passing Ployitos and emerging into the valley of La Paz, the granite is succeeded by hills of from five to seven hundred feet high of stratified volcanic ash, covered by a deposit of very hard porphyritic trachyte. These volcanic rocks are not extensively developed on the side of the Bay, but form a narrow strip along the base of the higher mountains forming the Cacachilas Range. The stratified ash has a low dip usually westward, though in some places, especially east of La Paz, it is very much disturbed, dipping in all directions. The new church now in process of construction in La Paz is of the solidified ash, which is sufficiently hard and of a good color for building purposes. We encountered no other volcanic rocks in place in this region, but I observed, especially near Santiago, in the gravels, numerous pebbles and occasionally large boulders of a light gray porphyry with crystals of white feldspar. Inquiry among the natives failed to elicit any information regarding similar rock in place, and the boulders have a rolled look, as if they might have travelled a long distance.

From the borders of the mica slate, on the road towards Todos Santos and northward, there is an entire change in the geology, and an accompanying one in the appearance of the country. The rugged mountains and beautiful tropical valleys disappear, and in their place we have broad, arid-looking plains, or at best flat-topped table-mountains, extending as far as the eye can reach, as tiresome in their monotony as the plains themselves. In general the structure of this, the middle portion of the Peninsula, is simply a series of non-fossiliferous sandstones lying on a granite base, the former often metamorphosed, especially on the eastern side. On the western margin these rocks are overlain, usually more or less conformably, though with occasional instances of non-conformability, by a comparatively thin series of sandstones and calcareous beds, often highly fossiliferous. The fossils, all, or nearly all, of living species, indicate for this group a very recent age, most probably Post-Pliocene. On the eastern margin, near the coast, these rocks are found in a few isolated patches lying very unconformably on the upturned edges, or abutting against inclined surfaces of the older sandstones, and in most cases filled with fossils in an excellent state of preservation. Overlying both these sedimentary formations, and often protruding through them in the form of dikes and volcanic rocks, are found porphyries, trachytes, and pumice. The elevation of the range commenced long before the deposition of the Post-Pliocene beds, as is demonstrated by the fact that those hardly ever attain an elevation of more than four or five hundred feet above the sea, and, on the west slope, where the disturbance has been least, they thin out almost imperceptibly along the eastern margin. An exception to this exists, however, in the high mountains of Santa Maria, which are capped by thin beds of fine-grained, soft sandstones, and a little limestone ; these, although without fossils, are without doubt members of the same formation.

A very interesting feature of the older beds, or Mesa Sandstones, as I shall call them for convenience, is the presence in them of immense numbers of fragments of volcanic rocks. These are markedly different in character from the more modern outflows, which have covered alike both formations, and, by their hardness, have assisted in preserving the tabular form of nearly all the hills. In some of the beds these pebbles and boulders are so numerous as to produce a conglomerate, in which the cementing sandstone forms a comparatively unimportant part. From the manner of their occurrence it is evident that their origin was somewhere east even of the present coast-line. About Magdalena Bay and towards Comondo and Purisima they are small in size, few in number, and very much rolled, as if they had been brought a long distance ; but on approaching that part of the coast which extends from Chuenca to Loreto, their number and size increase steadily and in the same ratio as the decrease in the amount of attrition to which they have been subjected. In no place have the rocks from which these boulders are derived been encountered, and they certainly do not underlie the Mesa Sandstones at any point where the base of the formation has been seen. At Sauce, and again at Santa Gertrudis, I have seen this rock lying directly in contact with the granite, but without any trace of an intermediate formation. The only solution of the difficulty, therefore, that has occurred to me is, that at the time of the deposition of the Mesa Sandstones, there was a body of land lying where is now the Gulf of California, and near the present position of Carmen Island, and that the volcanic boulders which make so important a part of these sandstones were derived from that region.

The line of elevation of this portion of the Peninsula is very close to the east coast. From La Paz to beyond Moleje the distance of the summit from the beach would not average more than fifteen miles in a direct line, and it is often less than five miles. The whole country is elevated with a slope so gentle as to be almost imperceptible, from the shores of the Pacific to this summit, and from there it descends to the Gulf so precipitously as to render the ascent very difficult and not unfrequently quite impossible. Neither is there any anticlinal axis, the mountains looking as if they had been broken off rather than pushed up ; and it is not improbable that more detailed investigation than I was able to make will demonstrate the existence of an enormous fault along this line of coast.

After leaving the mass of mica slate between Triunfo and Todos Santos, the road runs over gravel mesas or tables, which extend northward, frequently interrupted by water-courses and little valleys, for about sixty miles along the coast. These tables show in places a distinct terrace structure. At the point of the greatest development they are about thirty feet high each, one above the other. From this they fall to nearly nothing. Looking eastward can be seen, far inland, low, flat-topped hills, which gradually approach the coast and eventually, about eighteen miles north of the rancho of the Innocentes and perhaps fifty miles south of the Magdalena Bay, reach the beach. From here to Ballenas Bay they continue, sometimes close to the coast, at others retreating more or less inland, and always quite low near the Pacific, but rising gradually to the eastern summit, where they culminate in the high ridge of the Sierra Gigantea near Loreto, there reaching an elevation of over three thousand feet. These hills were formerly connected as one entire plain, but are now divided into innumerable flat tables, often separated by cañons of a thousand feet deep. At the Salada near Magdalena Bay, and about six miles inland, the cañon shows a good section of about sixty feet high. The rocks here are a fine-grained, soft sandstone below, overlain by soft, calcareous beds with many casts of fossils, all, so far as I could determine, belonging to living species. The same beds continue as far south as we saw this group of rocks, but on going eastward the limestones disappear within a few miles, having probably been removed by denudation. The underlying soft sandstones, interstratified with some white shales, still continue inland to a point a little beyond the old mission of San Luis Gonzaga, where they thin out and are underlain by a coarse-grained, more compact sandstone, filled with the volcanic boulders of which mention is made above. Before leaving this part of the coast a word about the large island of Margarita would be in place. We did not visit it, and could obtain no reliable information about it; but from its contour and its being reputed to contain veins of silver and copper, it is in all probability a mass of either granite or mica slate. About San Luis are many dikes of a light gray porphyry, filled with small crystals of white feldspar. These dikes, striking with great uniformity within a degree or two of the magnetic meridian, disturb both of the sedimentary formations for nearly twenty miles. The Post-Pliocene beds, which also contain a few boulders of volcanic origin probably derived from the underlying strata, are sometimes covered with a "pedregal"* of rounded pebbles which render travelling extremely unpleasant. Near San Luis the surface of the earth is covered in many places with flakes and scales of selenite, sometimes of several pounds in weight, and doubtless derived from the destruction of the shells which once existed in these rocks, and the chemical recombination of the constituent lime.

From San Luis to the eastern summit, above the Tinaja, the mesas rise with a gentle curve, the dip being to the southwest. No fossils were found; the Post-Pliocene had disappeared, but in one or two places patches of table-land were seen capped by thin sheets of basaltiform rocks. No traces of metamorphism were encountered here, though the hills but a few miles farther north are most unmistakably metamorphic. Nor did we observe any volcanic rocks in place on our trail; the nearest we saw were some small patches at the distance of several miles northwest of the rancho of Jesus Maria. Mr. Rémond, who made some explorations just north of La Paz two or three years ago, mentions that there are extensive tracts covered by volcanic beds in that region.

Descending the eastern face of the range at the Tinaja we find the rocks entirely unaltered and retaining so nearly a horizontal position that the dip cannot be detected in a short section; and, excepting one or two slight twists of very limited extent, the same remark will hold good for the whole face of the range to the Sierra Gigantea itself. Carmen Island, in the offing, appears to belong to the same formation, having a low dip to the northeast, with a slight disturbance at its southwest or higher extremity. At the Chuenca, about fifteen miles south of Loreto, we encountered the first traces of metamorphism. Here the sandstones lose to a great extent their sandy structure, but retain very markedly their stratification. This peculiarity exists almost everywhere where the rocks have been altered. The most notable exception to the rule is found near Moleje, where the loss of stratification is restricted to one or two hills only, and even there seems rather to be due to a complete crushing of the rocks by upheaval than to a blending of the strata. Half a dozen miles north of Loreto is a group of hills of Post-Pliocene age and highly fossiliferous. The largest of these is perhaps six hundred feet high, and is known as the Cerro de los Osteones. The fossils are in a pretty good state of preservation, and all living species, but the variety is not very great. Between the Mesa Sandstones and the Post-Pliocene is a ridge about three hundred feet high and perhaps two or three miles long. It is composed of a brown trachyte, and tilts the more modern formation to the east at an angle of 55° with a strike of N. 10° W. magnetic. Half a dozen miles farther north there are spots in the Post-Pliocene entirely destitute of fossils, their place being occupied by seams of selenite. The same fossiliferous rocks extend along the base of the range, resuming their horizontal position and gradually thinning out, the last encountered being near San Juan, and a few miles east of the base of the Sierra Gigantea.

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* This word, for which I know no exact English equivalent, is used to designate a tract covered with great numbers of loose stones. Many spots on the Pacific slope are so covered to a depth of several feet, and without a particle of soil visible over areas varying from a few acres to many miles in extent. I have adopted the word partly because of descriptive brevity, and partly because it is in common use wherever this state of things exists.

Between the Bay of San Juan and that of San Bruno there are some low hills of highly metamorphosed Mesa Sandstone, in one place exhibiting a distinct synclinal axis, the strike being still nearly north and south. On the inland side these are flanked by thin beds of more recent rocks, overlain by a heavy deposit of volcanic origin, principally grayish trachytes. South of San Bruno the same hills extend a few miles, eventually hidden by the Post-Pliocene beds. Going westward from San Juan to Sauce, at the base of the Gigantea the road first crosses a narrow alluvial valley, then passes between hills of horizontal Post-Pliocene, covered by the same trachyte found toward the coast; the lower of these two rocks abuts horizontally against the face of strata of highly metamorphic Mesa Sandstones, dipping at an angle of 35°. These sandstones, within a mile, assume a horizontal position, and in turn abut against a mass of granite which at this point forms the base of the Gigantea.

The granite is a small patch about four miles long and a mile wide, exposed by denudation, and the sandstones lie on and against it in such a manner as to prove that they have not been materially disturbed since their deposition. The enormous succession of beds, rising with an almost perpendicular face, and forming the whole height of the mountain, is unbroken except by a few dikes which also cut through the granite and the sandstones lying on its opposite side.

The section exhibited by the face of this mountain proves the origin of the immense sheets of volcanic rocks which cover so much of the surface of this region. Except the volcano of the Virgines and the few cones about San Ignacio, no true volcanoes occur on the Peninsula. The country has been covered by means of the inconspicuous dikes which, having exhausted themselves in inundating their neighborhood with a fiery deluge, have become at once and forever extinct.

From the summit of the Sierra Gigantea to the west coast, the section is practically identical with that described from Magdalena Bay to the Gulf. Regularly stratified Mesa Sandstones, cut by dikes and capped with a nearly continuous sheet of volcanic rocks, extend to near the edge of the plains. The metamorphism of the sandstones disappears by almost insensible gradation below Comondo, and almost simultaneously with the loss of the volcanic we find the Post-Pliocene coming in, first with a thin edge of limestone, almost entirely composed of fossils, and afterwards making up the entire thickness of the low mesas, so far as could be seen by the section in the arroyos. From San Juanico south for half a dozen miles is a tract a mile or two wide covered by barren sand-hills, and showing no underlying rocks. Back of this are low tables and rolling ground, formed by the lower beds of the Post-Pliocene, without fossils, but filled with seams of selenite, and in most places overlain by a deposit of volcanic rocks. This continues to near the mission of Purisima, where, the Mesa Sandstones coming in more or less disturbed, lying in gentle undulations, the Post-Pliocene covers them unconformably and rapidly thins out.

From the Purisima to the summit the older strata continue, slightly disturbed, and in the higher parts more or less metamorphosed. The metamorphism continues past the summit to the coast. Here, for the first time, there appears to be some trace of an anticlinal axis, the hills between the main crest and the gulf being more marked, and the rocks inclining in various directions, an easterly dip predominating. Near Moleje the disturbance seems to have reached its climax ; in some places the stratification is completely lost, the rocks being altered as if by the action of mineral waters, and looking as if they had been burned in a kiln. Considerable quantities of alum and sulphur are said to exist in the vicinity. Selenite also exists, but not in the quantities that have been reported by irresponsible parties, whose aim was to speculate on the credulity or love of gain of persons who were unable to test their veracity. The existence of sulphate of lime in some of the metamorphic rocks about Moleje renders it probable that at least a portion of them may belong to the more modern formation, since, should they prove to be the older Mesa Sandstones, this will be the first instance in Lower California where gypsum has been found in that formation. For about fifty miles north and along the coast the road continues on the east side of the main summit, crossing innumerable ridges, all made up of metamorphosed Mesa Sandstones, very much disturbed and with a prevailing southwestern dip, and a strike nearly parallel with the direction of the Peninsula. Soon after crossing the main ridge the rocks begin to lose their metamorphic character, and to lie more regularly, assuming again their gentle southwestern inclination. Just where the trail reaches the summit of the ridge are several large dikes of trachyte, the principal one of which strikes N. 55° W. magnetic, and, projecting above the surrounding rocks and soil, runs a mile or more like a wall. No further change takes place in the geology until within a mile or two of San Ignacio, where a fine little volcanic cone towers isolated above the surrounding tables and sends out a sheet of lava over everything in the direction of the Pacific coast. Almost at the same time the Post-Pliocene rocks show themselves under the volcanic, and in a few hundred yards reach the base of the section in every arroyo, the older rocks disappearing under them.

Going northeast from San Ignacio the section is the same, except that the volcanic does not end in a mile or two as towards Moleje. Peak after peak and ridge after ridge of trachyte, porphyry, and pumice succeed each other, forming an apparently continuous belt to the Volcano de los Virgines close to the Gulf coast. Turning more to the north and leaving the volcanic belt to the right, the trail strikes directly for the main range, and enters a highly metamorphosed and somewhat undulating mass of the Mesa Sandstones which here lose entirely for a time their "table-mountain" structure. The chain, here very jagged and broken in appearance, makes a sudden bend away from the main coast, and curving around again approaches it near Santa Gertrudis. From this part of the range the tables slope down as before, towards the Pacific; but instead of reaching the coast are cut off by a small range known as the Santa Clara Mountains, which are said to be granitic, and which extend almost all the way from the Bay of Ballenas to that of San Sebastian Viscaino. The region included between the before-mentioned curve of the main ridge and the Gulf coast is a barren, sterile tract, made up of low irregular ridges of metamorphic sandstone, without water or grass, and hardly able to support the straggling growth of cactus which alone gives a semblance of life to this most inhospitable waste. Water exists at but three spots on this side of the mountains; at Santa Marta, as a little stream trickling down a rocky bed; at Rosarita, as a spring without outflow; and again at San Juan, in a cañon close to the base of the ridge, as a little tepid spring, with a rivulet of but a few rods in length trickling out of it. From San Juan the trail climbs directly up the face of the mountain here called El Obispo (the Bishop), and entering the head of a rock cañon follows it down to Santa Gertrudis. While east of the mountain the usual number of slight disturbances exist, as soon as the summit is passed the sandstones resume their nearly horizontal position, and retain it almost without interruption, but without again losing their metamorphic condition.

Just at Santa Gertrudis a small mass of granite shows itself in the cañon, cut into and exposed by the denuding effects of the mountain stream. This is but a few rods in extent, and for the next two leagues on the road to San Borja the metamorphic sandstones continue, interrupted but once by a large and very peculiar looking dike of dark gray cellular trachyte. This is exposed by an excellent section of about forty feet high on the nearly vertical bank of an arroyo. The sandstone was uplifted from below over a space of a couple of hundred feet, the sides rising in regular and gently converging curves. The volcanic rock filled the cavity thus formed and broke through in the middle. Subsequently the whole mass was denuded to a nearly perfect level, and the section now presents the appearance of a very blunt wedge of trachyte with concave face, on which lie curved strata of sandstone. The dike which, from its greater hardness, resisted longest the denuding force, now strews the surface with its fragments for many hundreds of yards in every direction.

Soon after leaving this dike the trail enters a broad desert valley, covered with a scattered volcanic pedregal, and underlain by thin horizontal beds of unfossiliferous shales, resembling in every respect the Post-Pliocene farther south. In two or three leagues the shale thins out and disappears entirely, the only rock remaining being granite covered in places by a thin soil of granite sand. The higher hills are also granite, but are usually capped by beds of volcanic and sometimes sub-basaltiform rocks, with a marked inclination to the southwest. These may be considered as outliers of the mesa structure, and as the connecting link between the middle and northern sections into which I have divided the Peninsula. In some places the lavas are underlain by thin beds of Post-Pliocene, and near San Sebastian I observed a few hills in which the whole series was represented, the volcanic on top, overlain by Post-Pliocene, the Mesa Sandstone under this, and granite forming the great mass of the hill. The sedimentary rocks, where they thus exist, are quite thin, forming with the overlying volcanic cap a mass of not more, perhaps, than a couple of hundred feet in thickness.

North from San Sebastian as far as the south side of the range of hills behind Yubai, the whole country is capped, with greater or less regularity, by volcanic tables, which at San Borja are three or four hundred feet thick; and while they are very thin at Trinidad, southwest of San Borja, are underlain for a mile or two by from two to four hundred feet in thickness of Post-Pliocene sandstone and conglomerates.

About Rosarita the lavas usually disappear a few miles from the coast, the outer hills being low, rolling, and composed of a soft granite in which some copper stains have been observed and some unsuccessful mining done. One little group of hills about a mile to the northwest of Rosarita is capped by some Post-Pliocene outliers, entirely isolated, the nearest other locality of this rock which we saw being about fifteen miles distant. From this point to the valley of San Andreas the whole country is granite, cut by a dike of blackish porphyry at San Domingo, where there is a small spring of water.

Another dike at San Andreas acts as a dam, and forms quite a large lake and extensive marsh. In the valley of San Andreas and the adjoining low mesas — the northern a mile or two wide, the southern extending probably almost to Yubai — are beds of a soft, light gray sandstone, horizontally stratified and without fossils. Judging from analogy and lithological resemblance, I consider this to be Post-Pliocene.

About here, or rather between here and San Borja, the whole topographical system of the country undergoes a decided change. The table-lands, gently sloping up from the Pacific to near the Gulf coast, disappear. The western side, first broken into low rolling hills, begins to form a decided mountain-range, connected, it is true, with the eastern side, but by cross ridges instead of tables. The horizontally stratified Mesa Sandstones still retain a strong development, but cling close to the east coast, and eventually disappear in a series of low ragged ridges near the Bay of San Luis. The chain, however, is continued as a granite ridge some distance farther up the coast, finally sinking into a series of lava-capped hills, which gradually decrease in elevation until they are lost to sight in the distant deserts of the northeast. In the mean time the western range, constantly assuming grander proportions, covers with its spurs more than half the width of the Peninsula, and running northward continues across the boundary into Upper California, uniting with the San Gabriel Range.

From the northeastern margin of the Mesa of Santa Ana, where the trail strikes the high hills, the rocks are all of Mesa Sandstone, highly metamorphosed, forming quartzites, mica and talcose slates, and jaspers. These continue east to the coast, with variable strikes of from N. 24° W. to N. 46° W. magnetic, the prevailing dip being high to the northeast. Along the east face of the range they thin out and disappear about three leagues above Calamujuet, being replaced by granite.

At Santa Maria the summits of the highest parts of the ridge are capped by Post-Pliocene sandstones, covered with volcanic rocks. From here to Agua Dulce the same structure continues. The plains and valleys are of granite, the higher hills being capped as at Santa Maria. From Agua Dulce the hills fall rapidly, the Post-Pliocene eventually forming the valley land, the granite disappearing, and the few low tables that exist being made up in whole or in part of volcanic rock. This continues to the margin of the main chain, within a league of the deserted mission of San Fernando. The chain here consists of a core of granite on both sides of which are stratified volcanic rocks — ash, pumice, and harder lavas — lying highly uptilted against the granite, but assuming a horizontal position on the west side at a short distance from the granite.

These volcanic beds are soon succeeded by horizontally stratified beds of Post-Pliocene sands and gravels, which extend to the coast, covered in places with a rough pedregal. Following up the coast they form low tables, usually at some distance from the beach, but extending to within four leagues of San Telmo, where they are cut off by a spur of the higher range coming down to the ocean. As seen from the coast road the high chain inland appears to retain its structure as we saw it at San Fernando.

At San Quentin, near the salt ponds, are two or three hills composed of a hard, gray, cellular, volcanic rock, in parts having a sub-basaltiform structure. They are entirely isolated and cover a comparatively small area. From San Quentin there is no rock except the Post-Pliocene on or near the coast for two leagues northward to where the high range sends down a series of spurs. From here the features of the country suffer a marked change. The higher chain, with its granite core tipped and bordered with volcanic rocks, occupies the whole western half of the Peninsula from this point to the boundary. A border of rolling hills of trachyte and porphyry, about a league or a league and a half in width, forms the flank of the range. Crossing this, the road enters granite, which then continues uninterruptedly for more than ten leagues along the crooked trail to the old mission of San Vincente. At San Telmo there is a curious belt, of a mile or more in width, in which the granite presents almost the appearance of a conglomerate. It is filled with masses of a darker, finer-grained granitoid rock, very much harder than the including mass, and in fragments of all sizes from a cubic inch to two or three tons' weight. These included masses are, so to speak, sub-angular; that is to say, they present imperfect faces, of which all the corners and angles are blunted as if, having been torn off from the walls of a fissure, they have been entangled in the molten mass of what is now granite, their surfaces partially melted, and on cooling they have become thoroughly welded into the matrix. This welding is so perfect that on breaking the rock the cracks cross the line of union with even greater facility than they will follow it.

Six leagues from San Telmo is the Delphino Copper Mine, at a place called the Salada. The including rock is all granite, and though only one mine has been opened, it is claimed that there are croppings of many other veins in the vicinity. From the Salada, the road again bending slightly towards the coast, we encounter directly north of San Vincente more volcanic rock, but for the next half-dozen leagues only as caps to the higher points. Approaching San Tomas the volcanic belt widens, extending inland at least beyond this mission, which is twenty-one miles from the coast. Passing here, the road again approaches the coast and winds through and skirts hills of volcanic origin to the Sausal, twelve leagues. These rocks are mostly a black porphyry with small crystals of white feldspar. Along this part of the route the granite has almost entirely disappeared, being only met with at the base of some of the hills. But in a league northeast from the Sausal it reasserts itself, the porphyries and trachytes thinning out and disappearing as a series of low hills along the coast. From here to the boundary the granites make the entire range.

Along the coast for a few miles and extending up the valley of the Tia Juana are some low terraced tables of Post-Pliocene age, which abut horizontally against the granite. Those below the river end abruptly near its mouth, but those on the east side continue to flank the hills as a low mesa, reaching the coast near San Diego.

The region east of the summit of this range and north from Santa Maria is entirely unknown geologically. It is said to be a dry, arid desert, mostly covered with loose sand, but with some fertile little spots scattered through it, such as Santa Catarina. So far as I could learn by careful cross-questioning of several Indians, it appears that the mountains occupy the western half or two thirds of the Peninsula, the remainder being nearly level. It was with extreme regret that we felt ourselves compelled to neglect this district, but it was outside of the tract which we had undertaken to examine; the necessary delays we had been obliged to make elsewhere had kept us much beyond the time we had allowed ourselves; our mules were nearly exhausted as well as our funds; and, after three or four months of exile, without the sight of a letter or a newspaper, we were all anxious to catch the first possible glimpse of civilization, and find out what had been going on in the world. We therefore consoled ourselves with the belief that "that corner was n't of much account anyhow."

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